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Technical Memorandum 33-584

Volume IV

Tracking and Data System Support for the Pioneer Project

Pioneer 10—From January 1974 to January 1975
Pioneer 11—From May 1, 1973 Through Jupiter Encounter Period, January 1975

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Pioneer 11 support is described for the period from May 1, 1973 through Jupiter encounter, which ended January 3, 1975. The period covered involves operations in the interplanetary environment from the time of completion of the second trajectory correction to the start of Jupiter encounter, the implementation, planning, and testing that led to Jupiter encounter, and the operations during the 60-day encounter period for Pioneer 11.

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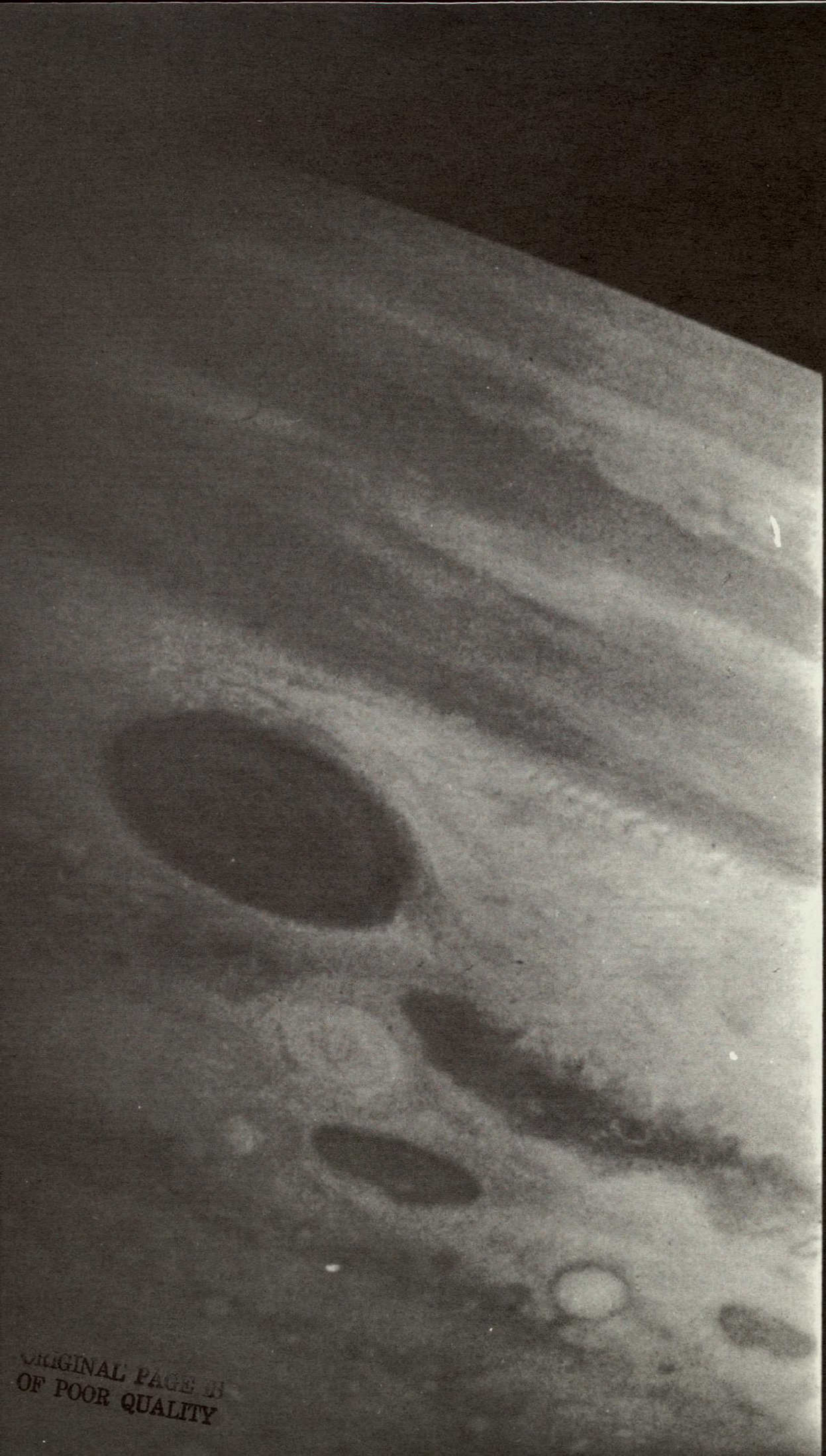

OVERLEAF: Closeup of the great red spot taken by Pioneer 11 on December 2, 1974 at a distance of 546,000 km from the center of the planet Jupiter.

PREFACE

This volume is one of a series of documents describing and evaluating support of the Pioneer 10 and 11 Jupiter missions with Project Management at the Ames Research Center of the National Aeronautics and Space Administration. The work described in this volume was performed by the Tracking and Data Acquisition organization of the Jet Propulsion Laboratory, with Dr. N. A. Renzetti as Tracking and Data Systems Manager for the Pioneer Project. In the time frame of this report, the principal Tracking and Data Acquisition involvement was the Deep Space Network of the Jet Propulsion Laboratory and the NASA Communications Network of the Goddard Space Flight Center.

ACKNOWLEDGMENT

The DSN Support Analysis section was extracted from DSN internal monthly reports published by the Network Operations organization under D. L. Gordon. The section of the report on occultation planning and results was written by A. L. Berman and R. S. Schlaifer. In addition, some material was abstracted from Ames Research Center reports.

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ABSTRACT

This report describes the Tracking and Data Systems support of Pioneer 10 from January 1974 through January 1975. This represents one year of post-Jupiter encounter investigation of the interplanetary environment beyond the orbit of Jupiter.

Pioneer 11 support is described for the period from May 1, 1973 through Jupiter encounter, which ended January 3, 1975. The period covered involves operations in the interplanetary environment from the time of completion of the second trajectory correction to the start of Jupiter encounter, the implementation, planning, and testing that led to Jupiter encounter, and the operations during the 60-day encounter period for Pioneer 11.

I. INTRODUCTION

A. MISSION DESIGN AND OBJECTIVES

The Pioneer Program, authorized under Project Approval Document 844-840-811, dated February 8, 1969, is identified as a Planetary Exploration Program and assigned to the Office of Space Science, NASA Headquarters. The project is managed by NASA's Ames Research Center (ARC), with Tracking and Data System (TDS) responsibility assigned to the Jet Propulsion Laboratory (JPL).

The primary objectives of the Pioneer 10 and 11 missions are to conduct exploratory investigations of the nature of the asteriod belt, the environmental and atmospheric characteristics of the planet Jupiter, and the interplanetary medium beyond the orbit of Mars to the extreme of spacecraft communications. A secondary mission objective is to advance the technology and operational capability for long-duration flights to the outer planets.

Pioneer 10 was launched on March 3 (GMT), 1972, and Pioneer 11 was launched April 6 (GMT), 1973. At the time of writing, both spacecraft have completed the first of the primary objectives, investigation of the nature of the asteriod belt, and the second objective in two successful Jupiter encounters. Meeting of the third of the primary objectives will require continued support of Pioneer 10 and 11 operations by the TDS through the end of this decade. The Pioneer 10 trajectory received a sufficient velocity change during its closest approach to the planet Jupiter so that the spacecraft will eventually become the first man-made object to escape the solar system. Every day that data are received from the Pioneer 10 spacecraft is a further penetration into new regions of space never before explored by man. Pioneer 11 was targeted so that the velocity change due to the planet Jupiter will result in a flyby of the planet Saturn in 1979.

The earlier history of the Pioneer Projects is outlined in Volume I of this series.

B. PIONEER PROJECT MANAGEMENT AND JPL SUPPORT ORGANIZATIONS

The Office of Space Science, NASA Headquarters, is responsible for the planetary programs. The Pioneer Program Manager headed all activities of the Pioneer Project. NASA's Ames Research Center, located at Moffett Field, California, was in charge of all management coordination and control aspects for the Pioneer missions. The Pioneer Project Office (PPO) was headed by the Pioneer Project Manager, who was supported by a project staff. In addition, several government-sponsored organizations supported the Pioneer 10 mission with specific services. The Space Nuclear Systems Division of the Atomic Energy Commission controlled the development and production of the radioisotope thermal electric generators (RTGs). Teledyne Isotopes was the prime contractor for these generators. The Experiment System, Spacecraft System, and Mission Operations System (MOS) were supported by individual teams of ARC. The spacecraft contractor was TRW Systems Group, TRW, Inc.

Several organizations of JPL were involved in supporting the Pioneer 10 mission. These organizations are shown in Fig. 1. Responsibilities of the respective JPL organizations are briefly as follows:

(1) Tracking and Data Acquisition (TDA). Responsible for TDA planning, Deep Space Network (DSN) systems and subsystem engineering, and operation of the DSN.

(2) Office of Computing and Information Systems (OCIS). Responsible for Mission Control and Computing Center (MCCC), associated supporting research, engineering, and operations.

(3) Flight Projects: Operation Support Coordination Office. Responsible for Ground Data System (GDS) coordination and interface with the project. This involves assuring that the interface between the TDA and Office of Computing and Information Systems (OCIS) will result in a GDS that meets project requirements.

(4) Telecommunications Division. Responsible for DSN research and subsystem implementation.

(5) Mission Analysis Division. Responsible for the navigation support of the Pioneer Project.

This document is a report on only that portion of JPL support provided as a part of the TDS which encompasses only the organizational elements (1) and (4), above. Support by the other JPL organizations involved in Pioneer 10 is described only insofar as they interacted with the support provided by the TDS.

C. MAJOR MISSION EVENTS AND CURSORY SCIENTIFIC RESULTS

1. Solar Conjunctions

In February 1974, both Pioneers 10 and 11 went through a solar conjunction. Simultaneous with the solar conjunction was the extensive post-Venus closest-approach period of Mariner Venus-Mercury. Since Mariner Venus-Mercury 1973 (MVM'73) approached Venus from the dark side, it was during this post-encounter time period that the majority of the good Venus imaging took place. MVM'73 required 64-m coverage in this time period in order to achieve the maximum return of imaging data. Pioneers 10 and 11 also required 64-m coverage in order to safeguard the spacecraft during the solar conjunction. Closest approach of MVM'73 to Venus occurred on February 5, 1974. The centers of solar conjunction occurred on February 19, 1974 for Pioneer 10 and on February 21, 1974 for Pioneer 11. Detailed description of the solar conjunction is contained in Subsection V-C.

2. Pioneer 11 Jupiter Encounter

The principal differences between the Pioneer 10 and 11 encounters important to the science observations were: (1) Pioneer 11 went much closer to the planet; (2) the outbound leg of the trajectory occurred at a different local time, that is, at a different phase relative to the Sun and out in a much higher magnetic latitude than Pioneer 10; and (3) repeat observations at a different epic in time which will help differentiate between spacial and temporal fluctuations in the observed phenomenon.

As with the Pioneer 10 Jupiter encounter, Pioneer 11 detected multiple bowshock crossings as it approached the planet Jupiter. It, therefore, indicated that extensive fluctuations in the magnetosphere of Jupiter are most likely a common occurrence. Jupiter has very large moons, which are very close to the planet compared to the planet's radius. For this reason, there was considerable interest before the Pioneer 11

encounter as to whether there were interactions between the moons and the magnetosphere. The spacecraft trajectory carried Pioneer 11 very close to the flux tube of the satellite Io. An interaction of the magnetosphere with the orbit of Io was not immediately apparent in the helium vector magnetometer data; however, there did appear to be noticeable effects due to Ganymede and Callisto. Since the Pioneer 11 trajectory swept out a much wider range of longitude than Pioneer 10, it is expected to have a much better map of the magnetic field and, in particular, the dipole component of the magnetic fields orientation, location, and magnitude than was possible with Pioneer 10 data alone. There were indications from the measurements by the dual fluxgate magnetometer that the magnetic field of the planet closer than 3 Jupiter radii could not be successfully represented by an offset dipole but was more complex, and that tentative modeling of the more complex field could help explain the decimetric radio emissions from Jupiter which are observed on Earth.

The inner core or dipole region is where there is strong trapping of particles. For high-energy protons in the region greater than 35 million electron volts, Pioneer 10 measured a peak at about 3-1/2 Jovian radii, and the Pioneer 10 data ended with the downward slope after this peak. Pioneer 11 went much closer and measured the same peak as Pioneer 10, and there are indications of a second peak closer in to the planet. Similar peaks were observed on the way in and on the way out, thus indicating that the peaks are caused by a contained group of particles in the magnetic field that form a shell-like structure around the planet. These protons are the same kind of energy as is produced in a cyclotron on Earth, but produce no radio emission and are therefore undetectable except by <u>in situ</u> measurements. The inner peak for low-energy protons had an intensity of approximately 150 million protons per square centimeter per second. This core structure of charged particles appears to be one of the more stable features of the planet Jupiter.

Measurements of the electrons in the core region around Jupiter in the energy spectrum of those electrons capable of producing radio emissions indicate perhaps 10 times the abundance as was expected based on Earth observations of radio emissions. Proper modeling of this electron content versus the radio emissions is very important to astrophysics since ground-based measurements of radio emissions are used to deduce electron content in distant objects.

Concentration of high-energy protons and electrons around the plasma sheath discovered by Pioneer 10 was confirmed by Pioneer 11. It appears that there is an acceleration mechanism in effect around the plasma sheath region. The 10-h periodicity in the radiation intensity, which was assumed to be tied more closely with the equatorial plane passage of Pioneer 10, was also evident in the higher latitude data received by Pioneer 11. A sweeping effect of the inner moons indicated by Pioneer 10 was reconfirmed by Pioneer 11. There is also confirming evidence that bursts of electrons and protons seemed to escape Jupiter's magnetosphere. This is implied by observation of the 10-h periodicity in particle count as the spacecraft approached the magnetosphere as early as 6 mo before closest approach to the planet.

The 2-mo-long imaging of the planet Jupiter enabled viewing changes in the visible features of that time scale, and the year-spacing between Pioneers 10 and 11 enabled seeing longer-term changes in the visible features. Pioneer 11 appeared to show a little more structure in the red spot and crisper definition of flow around the red spot. The convective plumes of rising gas about the equator were still present in the Pioneer 11 pictures.

Because of the change of Pioneer 11 to a Saturn trajectory, the ultraviolet photometer did not get to view the planet Jupiter during this flyby. However, the ultraviolet photometer did view the Galilean satellites of Jupiter, and preliminary indications are that the hydrogen cloud observed associated with Io during Pioneer 10 was confirmed as still existing, whereas it appears that Ganymede and Callisto do not have a hydrogen cloud associated with them.

The meteoroid detector measured a higher concentration of small particles in the Jupiter environment than in interplanetary space, and comparison of the Pioneer 10 and 11 data indicates that these particles are being focused into Jupiter from their solar orbits and are not in orbit around the planet.

The occultation experiment seemed to be highly successful again, with all open- and closed-loop data successfully recovered. The experimenter expected to see less multipathing due to layering in the Pioneer 11 data than in the Pioneer 10 data because of the different trajectory. Rather surprisingly,

though, the Pioneer 11 data seemed to be even more complex than the Pioneer 10 and will require extensive analysis in order to draw firm conclusions.

The celestial mechanics experiment received very good data. The nature of the Pioneer 11 trajectory meant that the possible gravitational effects of the planet Jupiter were observed over much wider latitudes, and indications are that from a gravitational standpoint Jupiter is a very smooth body in hydrostatic equilibrium; that is to say, no evidence of mass concentrations was observed. The perturbations of the trajectory due to the large satellites of the planet Jupiter will enable accurate determination of the masses and estimates of the densities of the four Galilean satellites. Preliminary results indicate that the two inner satellites, Io and Europa, appear to be denser than the outer-two Galilean satellites, Ganymede and Callisto, which will have implications as to what their formation process may have been.

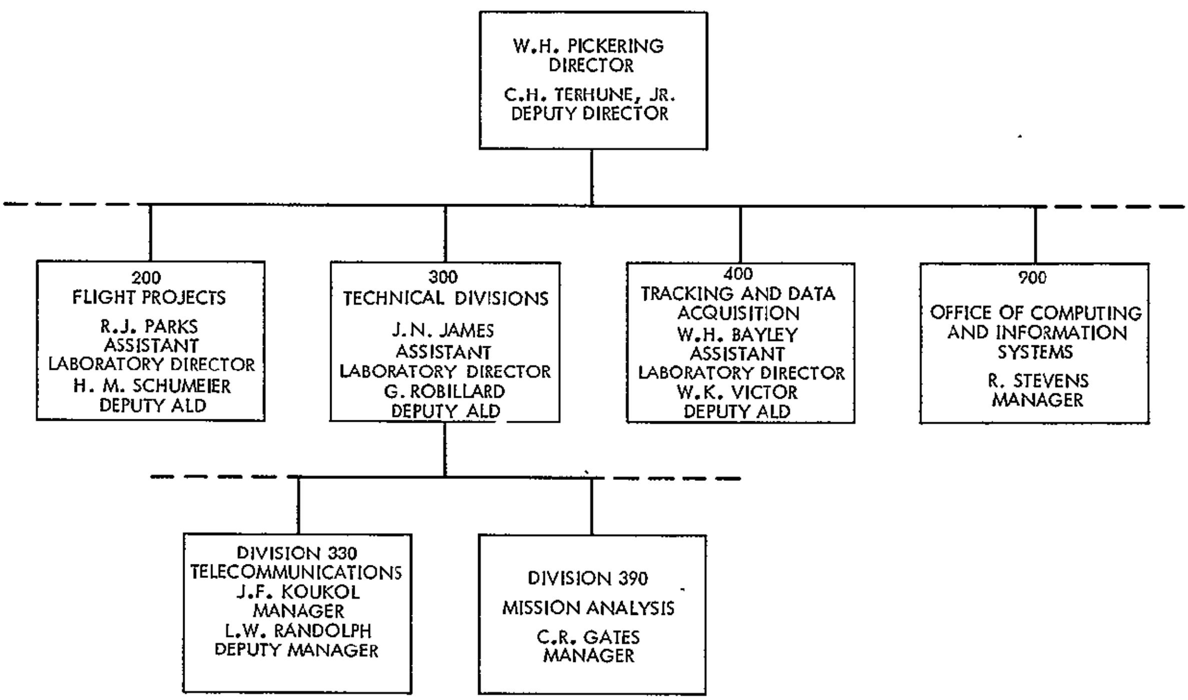

Fig. 1. JPL organizations supporting Pioneers 10 and 11 as of January 1975

II. TRACKING AND DATA SYSTEM

A. TRACKING AND DATA SYSTEM ORGANIZATION

The TDA organization involved in support of the Pioneer Project is shown in Fig. 2. The manager of the DSN Systems Engineering Office also serves as the TDS Manager for the Pioneer Project. The TDS Manager acts as the interface between the project and the TDS support agencies to match requirements with the capabilities of the support agencies to establish a compatible integrated system of tracking and data acquisition resources which are then called the "Tracking and Data System." The DSN Manager acts as the Assistant TDS Manager for Pioneer and is responsible for all DSN support for the Pioneer Project. The DSN Manager is responsible for negotiating the requirements and commitments with the Pioneer Project for the DSN and is responsible for assuring that all capabilities required are planned and implemented on schedule to meet project requirements.

Under the Network Operations section (Fig. 3), there is a Network Operations Project Engineer (NOPE) assigned for Pioneer. The NOPE is responsible for all DSN Operations organization support of the Pioneer Project. This involves achieving operational readiness, producing operational procedures, the DSN scheduling activity, and the conduct of operations. Under the Network Operations Control Group, a Network Operations representative is assigned to Pioneer. The Network Operations representative is responsible for coordinating the day-to-day operational activities in support of the Pioneer Project.

B. DSN FACILITIES AND THE GROUND DATA SYSTEM

The Ground Data System used to support Pioneer 10 up to September 1974 and Pioneer 11 through Jupiter encounter was described in Subsection II-B of Volume III in this series. The configuration for the Pioneer 11 Jupiter encounter was essentially identical to that used for Pioneer 10. The block diagram contained in Volume III is repeated here as Fig. 4. An additional unique aspect of the Pioneer 10 and 11 missions is that they are the first unmanned missions supported by JPL which have involved a Remote Control Center (RCC). The GDS as it exists involves three major elements which are separated geographically. The first is the Deep Space Stations (DSSs), which are located around the world; the second is the MCCC and

Network Operations located at JPL; and the final element is the Pioneer Mission Operations Control Center (PMOCC) located at ARC.

1. TDS Portion of the Ground Data System

The TDS portion of the GDS involved the DSS, the network control functions located at JPL in Pasadena, California, and the NASCOM network, including the Ground Communications Facility (GCF), a portion of the Deep Space Network.

The Deep Space Station configuration was essentially identical for all phases of Pioneer 10 and 11 mission support and is shown in the block diagram of Fig. 5.

The ground communications network used to support the Pioneer 11 Jupiter encounter is shown in Fig. 6.

The location of each of the Deep Space Stations involved in Pioneer 10 and 11 support is shown in Fig. 7. Typical 26- and 64-m antennas of the Deep Space Network are shown in Fig. 8.

2. The Implementation of the Direct Mode

a. Introduction. As was described in more detail in Volume III, Subsection II-B, the data flow from the PMOCC passed from ARC via high-speed data line (HSDL) to the Computer System located at JPL, where extensive processing took place, and then the data flowed on to the Deep Space Stations. Recognizing the complexity of the GDS as it existed, Pioneer Project initiated an activity to implement a Direct Interface between the PMOCC and the Deep Space Stations. Over several months, representatives of the DSN and the PPO jointly formulated a detailed technical plan for the implementation of such a Direct Interface. The technical plan was completed and underwent a formal review and acceptance by DSN Management and PPO Management.

The basic objective in implementing the Direct Interface was to simplify the GDS for Pioneer Operations by eliminating Pioneer telemetry and command processing in the 360/75 computers of the MCCC located at JPL and interfacing the PMOCC at ARC directly with the stations. This simplification of the GDS was to reduce the complexity of operational interfaces and improve reliability since a major element, with its independent

mean time between failure and mean time to recover, would no longer be in series with the data flow. The direct mode would also reduce the interaction between the Pioneer Project and other in-flight missions since only the radio metric data processing for Pioneer was to remain in the multimission co-resident 360/75 environment.

b. Design Guidelines. The following general requirements were used in formulating the detailed design of the Direct Interface.

In the direct mode and during the implementation period, Pioneer 10 and 11 operations should not be degraded. Because of the time scale of the planned implementation, it was decided that the Pioneer 11 Jupiter encounter should not be supported in the direct-interface mode, but rather in the same fashion that the Pioneer 10 Jupiter encounter was supported.

Simplicity of the resulting interface was a primary concern. For this reason, the development of additional interactive computer-to-computer interfaces between ARC and the Deep Space Stations was avoided. It was also a design objective that both the Pioneer Project and the DSN should be able to self-test that they had met the agreed-upon interface prior to calling upon each other to test across that interface.

In order for the implementation of the Direct Interface to be cost-effective, it was deemed necessary to develop an implementation schedule which matched that of the Network Control System (NCS). This was so that when the Pioneer processing was no longer necessary in the 360/75 for Pioneer Project purposes, it would also no longer be necessary for DSN Network Operations Control (NOC) purposes.

The DSN is ordinarily responsible for the quality of the data at the point they are delivered to a Mission Operations Control Center (MOCC). In the case of the MOCC located at ARC, there is no DSN equipment or personnel at the ARC end of the high-speed data (HSD) system to monitor the quality of the incoming data. For this reason, it was agreed that the Pioneer Project would be responsible for assessing the quality in realtime of the data flowing into the PMOCC.

c. Detailed Design of the Direct Interface. The functional block diagram for the telemetry and command portion of the Direct Interface

Ground Data System is shown in Fig. 9. The Telemetry System involved the implementation in the realtime Sigma 5 system at ARC of additional realtime analysis functions and a logging function for the purpose of producing data records.

The interface for producing the Master Data Record (MDR) for the Telemetry System was to eventually be the Intermediate Data Record (IDR), which will be produced in the Network Control Data Processing Center. The IDR will be shipped from JPL to ARC and undergo processing in an off-line Sigma 5 computer in order to produce the Master Data Records and the resulting Experimenter Data Records. The IDR will be a Network Control System capability in early 1976. In the time frame prior to when the IDR is available, the Telemetry MDR will be produced by the PMOCC using a limited selected recall directly from the Deep Space Stations. This recall is ordinarily performed during the one-hour post-pass. In order to determine the required recall, realtime accountability software was implemented in the Sigma 5, which produces a summary of missing data upon request. From that summary of missing telemetry data, an operator at ARC is able to select by computer input a subset of data gaps which should be recalled. A message is then automatically produced by the Sigma 5 and transmitted over high-speed data line to a line printer at the Deep Space Stations to list for the station operator the outages which should be recalled from the Digital Original Data Records (DODRs). No implementation was required by the DSN for this system of doing telemetry data recalls since the message produced by the Sigma 5 was compatible with the DSS capability of receiving text messages from the Network Operations Control Center (NOCC).

The Flight Project Command System was implemented in a PDP-11 computer at ARC and was designed to interface with the DSN Mark III-74 Telemetry and Command Processor software, sometimes known as the "Command Redesign." The command message construction, verification, and high-speed block formatting functions are performed by the PDP-11 computer system. Response message blocks returning from the Deep Space Station are routed to the PDP-11 for verification, and to the Sigma 5 system for post-transmission processing. Mode change and recall request messages are generated by the PDP-11 computer. Initialization of the DSN Command System takes place from the NOCC, although backup initialization can be accomplished at the DSS in the event of an NOCC failure. In order for the

NOCC to have access to the Command System at the DSS over the same single high-speed data line that interfaces with the PMOCC, a special piece of hardware was developed at JPL. This equipment, known as a Filler Multiplexer, detects filler blocks in the data flowing from the PMOCC and replaces the detected filler blocks with high-speed data blocks from the NOCC. There were three Filler Multiplexers implemented for the Direct Interface.

The Command MDR is produced in the PMOCC, utilizing the same log tape function which is used for Telemetry Data Records. Ordinarily, any missing command messages are provided by the Network Operations Control Center, via voice or written message, to the PMOCC.

The flow of radio metric data for navigation purposes was unchanged in the Direct Interface and is pictured in Fig. 10. The only difference between the Tracking System end-to-end in the Direct Interface and in the previous GDS is the addition of the off-line Network Operations Control Center for the purposes of DSN operations control and the deletion of DSN operations control functions from the 360/75 realtime system.

It was mentioned above that the Direct Interface utilizes the DSN Mark III-74 Telemetry and Command Processor software. The advantages of using this new software in the Direct Interface were that Pioneer Mission Operations would then be using the same new generation of multimission software, which was to be used for all other missions without the MCCC having to implement this capability for Pioneer in the 360/75. The disadvantage of using the new software was that when the direct mode was utilized between Ames Research Center and the DSS, the command and telemetry formats were not compatible with the existing 360/75 realtime system. This meant that it was not possible to phase the implementation by a gradual buildup of capability, such as implementing the Command System first, then the Telemetry Realtime System, and then the Telemetry MDR. Instead, the Direct Interface had to go into operation with the full required capability at one time. Because of this, it was decided to phase the implementation by spacecraft, placing Pioneer 10 operation in the direct mode first prior to Pioneer 11 Jupiter encounter and adding Pioneer 11 to the Direct Interface immediately after Jupiter encounter.

d. Implementation of the Direct Interface. The implementation of the Direct Interface involved principally software development at ARC, but was dependent on the implementation of the NCS project. The implementation plan called for having the Direct Interface operational for Pioneer 10 on September 3, 1974 and on Pioneer 11 on January 15, 1975. The operational date for Pioneer 10 was a compromise between avoiding the Pioneer 11 Jupiter encounter time frame and waiting for the NOCC to be fully operational. As a result, Pioneer 10 in the direct mode used the NCS Block I capability which became operational on November 1, 1974. Final acceptance testing of the direct mode took place during the month of August, concurrent with extensive activity in preparation for the Helios launch and the Pioneer 11 Jupiter encounter. This scheduling was deemed necessary because postponing the implementation of the Direct Interface until after the Pioneer 11 Jupiter encounter would have placed it on top of the Helios first perihelion, which was to be in January and February 1975. Pushing it beyond the Helios first perihelion would have placed it on top of the heavy Viking preparation activity that would be in full swing at that time.

It was anticipated that the most difficult part of the interface to develop would be that portion associated with Telemetry Data Records. Previous experience with developing Telemetry Data Record interfaces on both Pioneer and other missions had shown that a fair amount of operational resources are consumed before the data record production becomes routine. A principal design aspect in the Direct Interface, which it was hoped would alleviate some of these previous problems with data record production, was that the accountability in the Sigma 5 is by high-speed data block number rather than by data time. This is the same concept which will be used in the design of the NOCC IDR capability. The validity of this design concept seemed to be proven because the transition of data record production from the MCCC to the PMOCC for Pioneer 10 in September 1974 went remarkably smooth with only minor procedural problems.

The transfer of Pioneer 10 to the Direct Interface went on schedule on September 3, 1974.

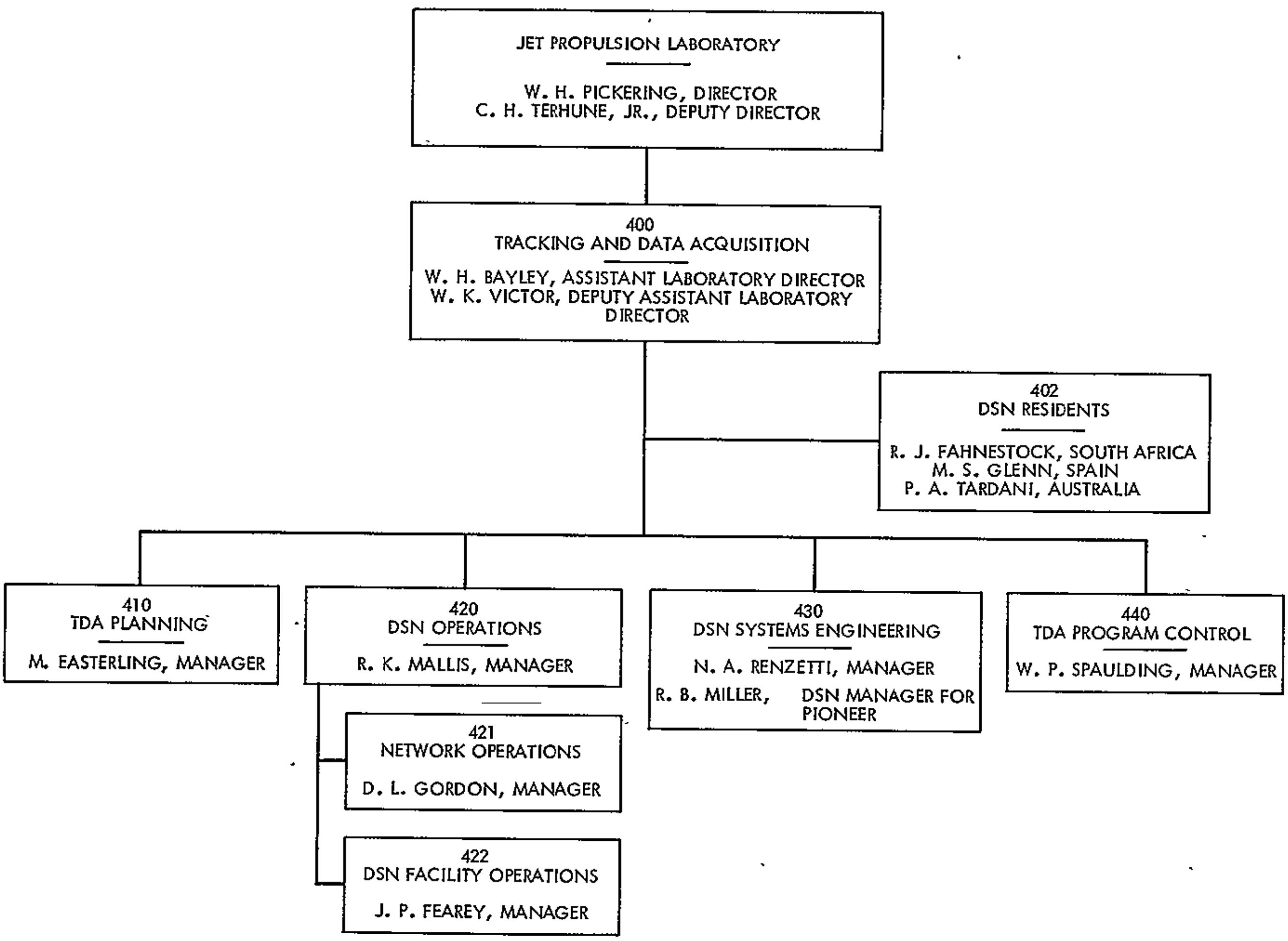

Fig. 2. Tracking and data acquisition organization in support of Pioneers 10 and 11 as of January 1975

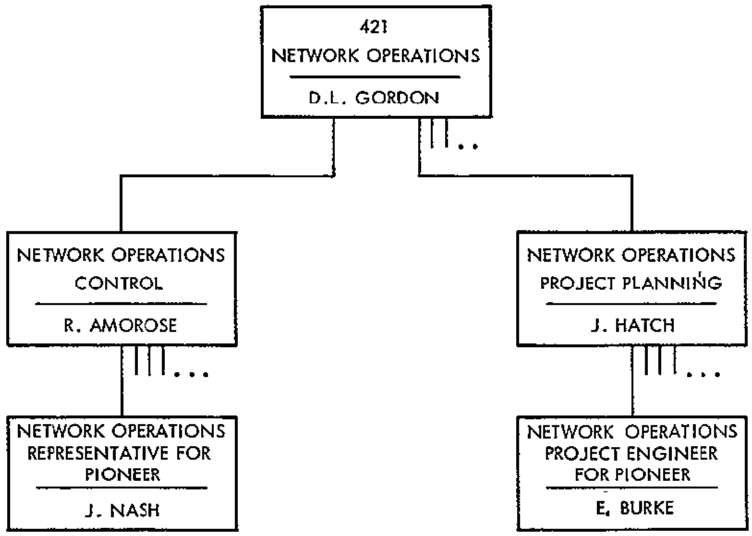

Fig. 3. Network Operations Pioneer interface as of January 1975

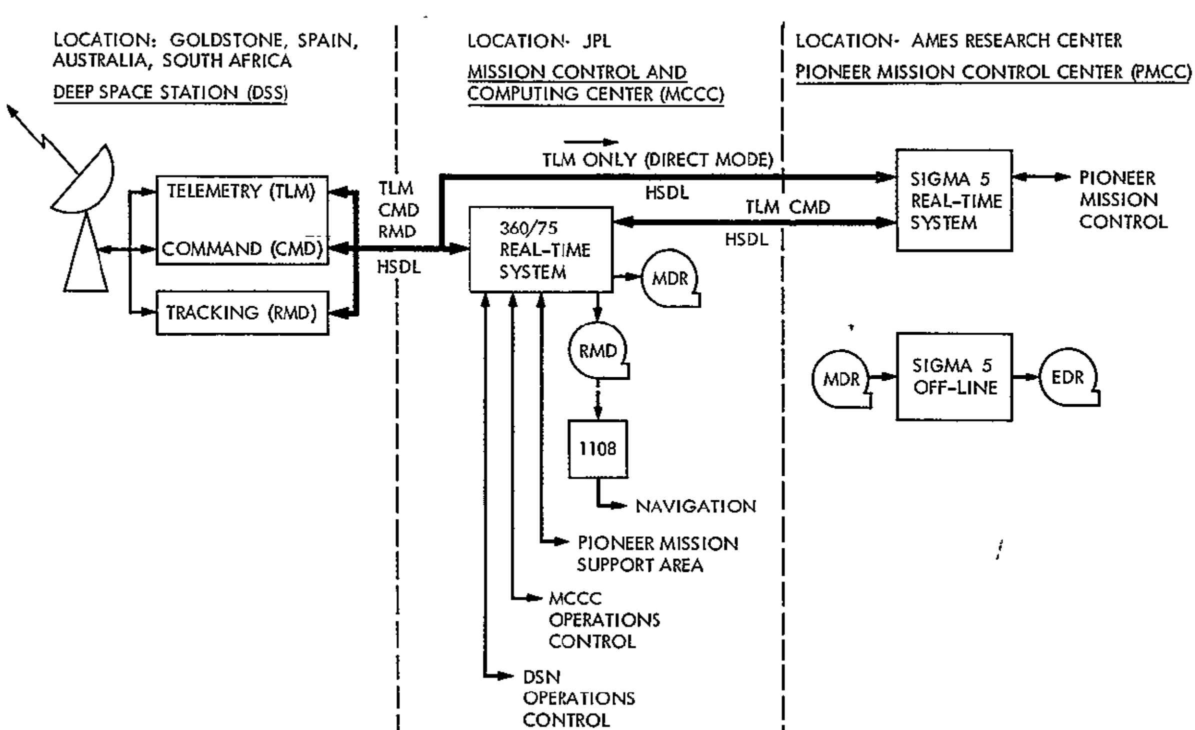

Fig. 4. Pioneer 10 and 11 Ground Data System configuration through January 15, 1975

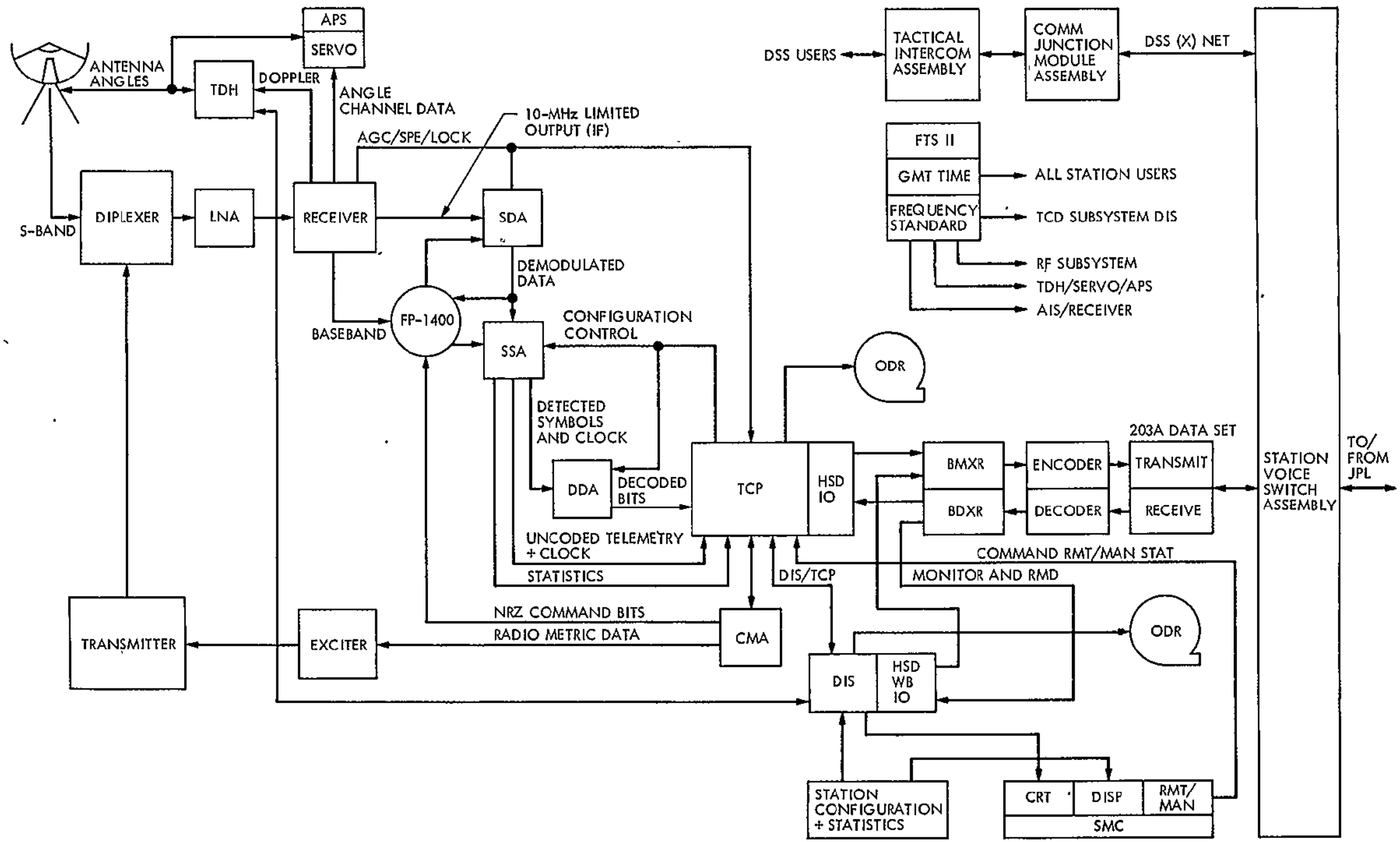

Fig. 5. Deep Space Station block diagram

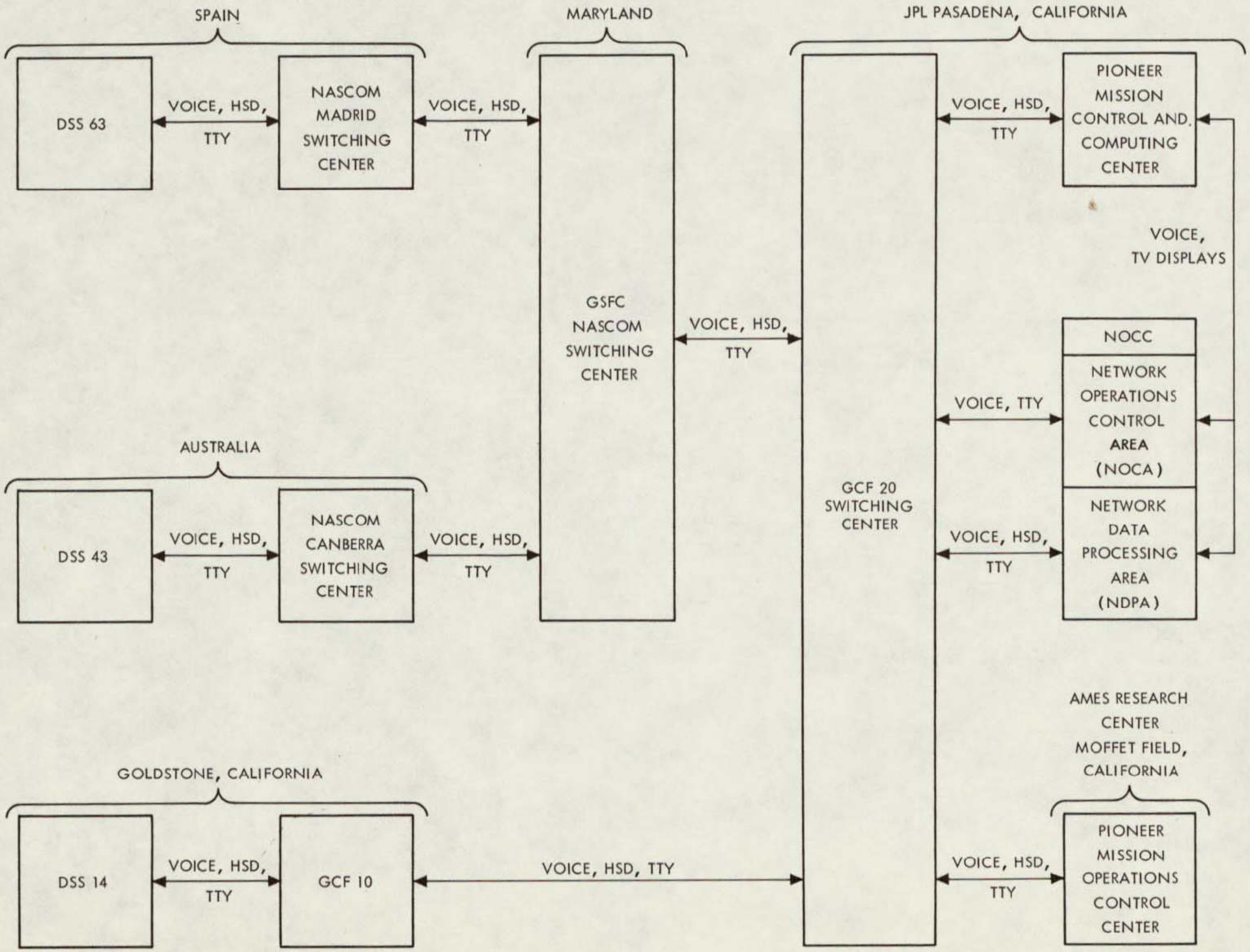

Fig. 6. Ground Communications System configuration during Pioneer 11 Jupiter encounter

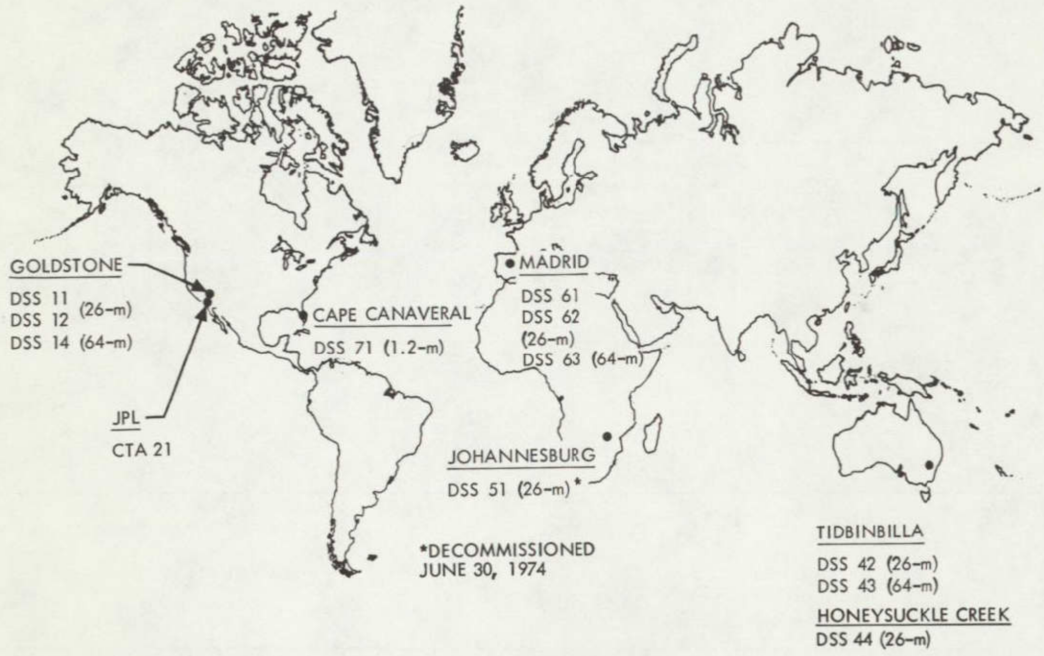

Fig. 7. DSS support for Pioneers 10 and 11 during period of this report

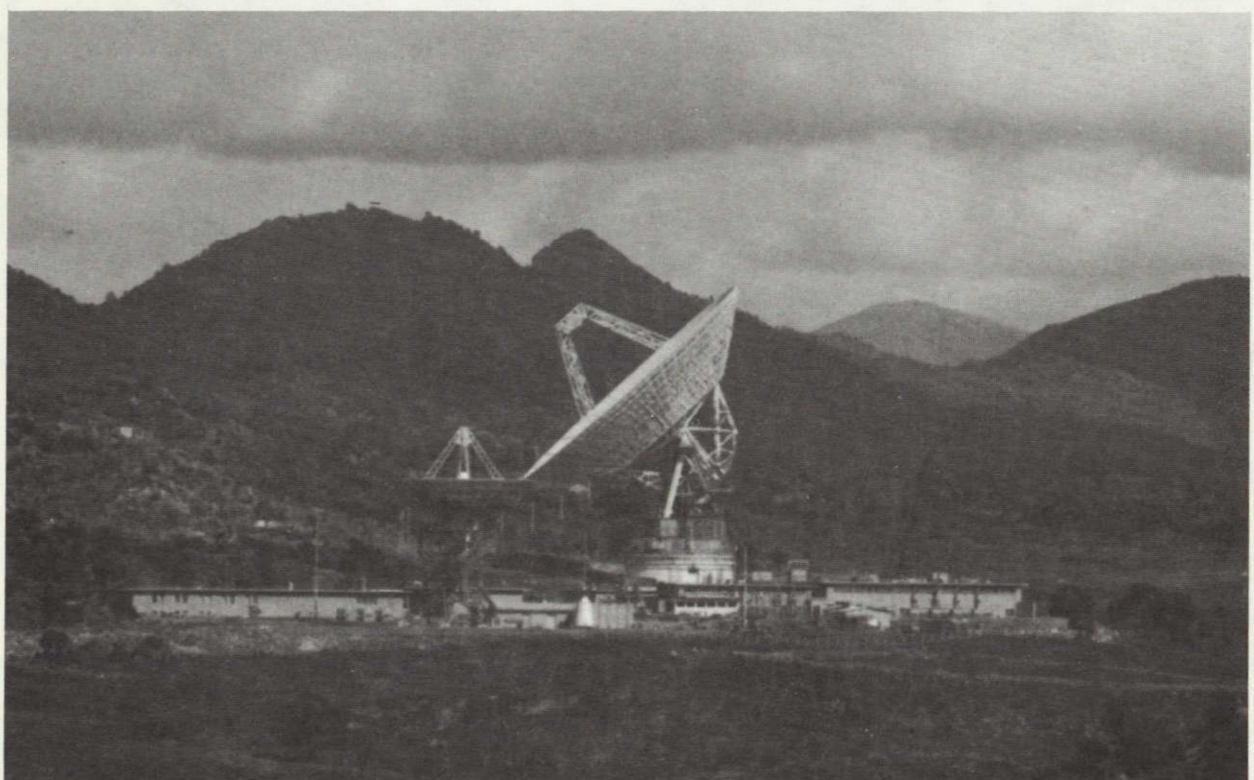

Fig. 8. DSS 61 (26-m) and DSS 63 (64-m) antennas of the Deep Space Network located near Madrid, Spain

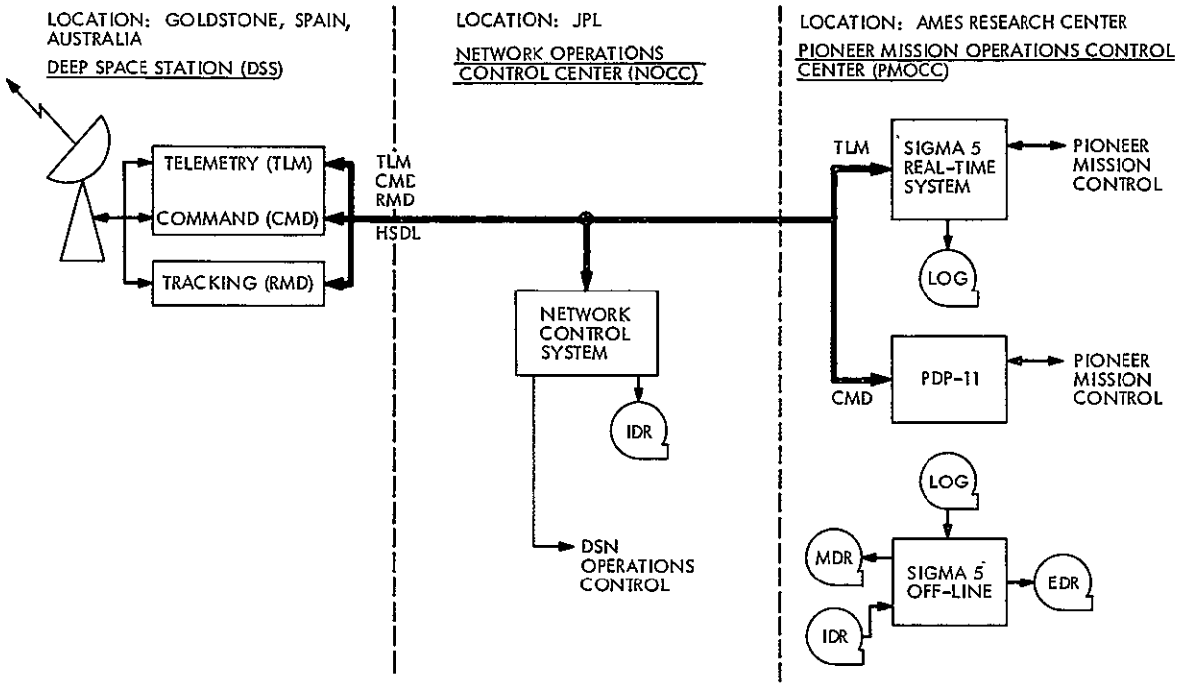

Fig. 9. Pioneer 10 and 11 Direct Interface Ground Data System configuration for telemetry and command

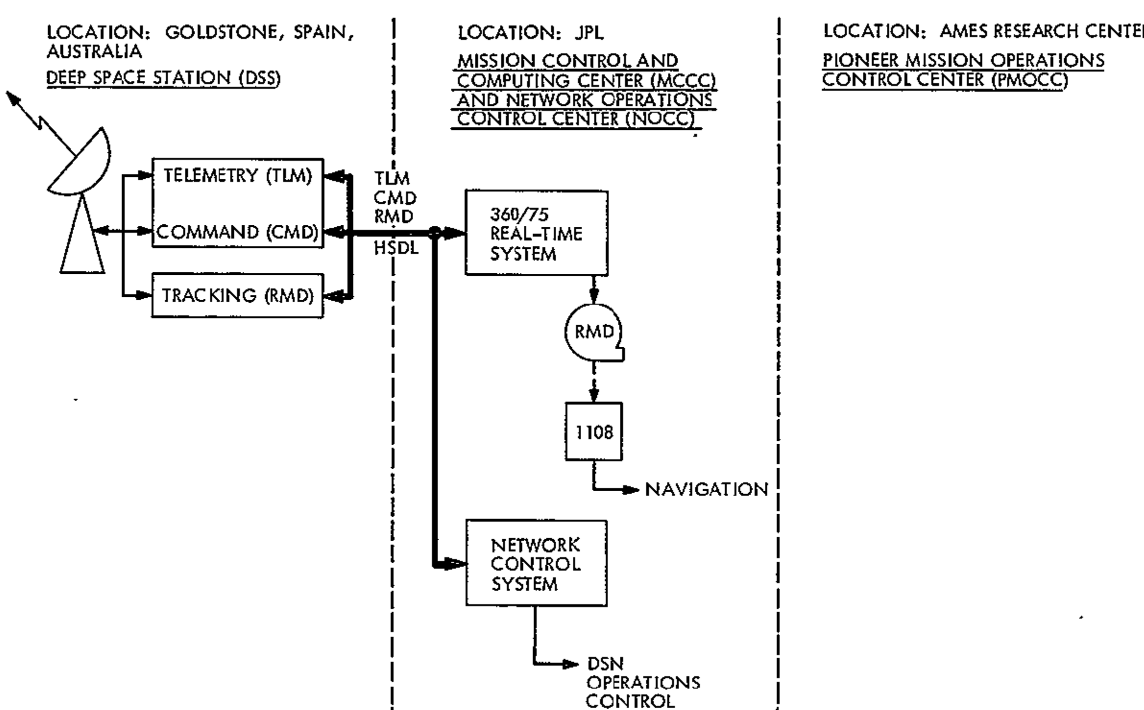

Fig. 10. Pioneer 10 and 11 Direct Interface Ground Data System configuration for radio metric data generated at the Deep Space Stations

III. MISSION PROFILE

A. INTRODUCTION

The Pioneer 10 and 11 basic mission concept and spacecraft were described in Section III of Volume III of this series. The spacecraft is pictured in Fig. 11.

The complement of scientific experiments on the spacecraft was also described in Volume III, Subsection III-B. The complement of experiments is identical on Pioneers 10 and 11, except that Pioneer 11 carries one additional experiment, a dual fluxgate magnetometer (see Table 1).

B. PIONEER 11 JUPITER ENCOUNTER PROFILE

Pioneer 11 was to have the closest approach to the planet Jupiter on December 3, 1974 at 0522 GMT. The spacecraft was to pass within 1.6 Jupiter radii (114,000 km) from the center of the planet with a velocity at closest approach of 48 km/s. At that time, the spacecraft would be 732 million km (4.9 AU) from Earth. The encounter support period was defined as closest approach ±30 days, which is from November 3, 1974 through January 3, 1975. The 60-day encounter period corresponds to ±380 Jupiter radii from the planet. This may seem like an excessively long encounter period until it is compared with a Venus or Mercury encounter. The time period around Venus or Mercury in a typical flyby trajectory, which would correspond to ±380 planetary radii, would be only ±2 days.

The 60 days around Pioneer 11 Jupiter periapsis passage were to be very much the same level of activity as around the Pioneer 10 Jupiter encounter in December 1973. In the 60-day time span, critical commanding was planned to be on the order of 8 hours a day until the critical encounter phase, which extended from -95 to +95 Jupiter radii (corresponding to November 26 through December 9, 1974), where there was 24 hours a day of critical command activity planned. The spacecraft was to enter the bow shock of Jupiter as early as November 25 and depart the bowshock as late as December 11. The magnetophase was expected to be crossed inbound as early as November 27 and outbound as late as December 8. There were both solar and Earth occultations. Viewing of the Galilean satellites with several of the onboard instruments was also planned; however, there was not to be a

satellite radio occultation as there was of Io by Pioneer 10. A smaller number of commands was necessary for Pioneer 11 than for Pioneer 10 Jupiter encounter because several of the problems in the Pioneer 10 imaging photopolarimeter (IPP) discovered after launch were corrected prior to the Pioneer 11 launch. This meant that the total number of commands transmitted in the 60 days of encounter was to be in the region of 12, 000 commands. This was 28% less than for Pioneer 10.

C. TRAJECTORY CHARACTERISTICS

Pioneer 10 and 11 launch and early cruise trajectives were described in Volumes I and II. The Pioneer 10 Jupiter encounter trajectory was described in Volume III.

Pioneer 10 will continue to move out from the Sun and eventually escape our solar system. It is anticipated that with the existing 64-m antenna configuration with a 12-Hz loop in the receiver, useful telemetry from Pioneer 10 will be received out to about 19 AU which corresponds to about a -164. 5-dBmW received carrier power. This range will be reached at about the end of March 1979.

Figure 12 shows the Pioneer 10 and 11 targeting points at Jupiter encounter. Speaking in terms of the direction that Jupiter moves in its orbit around the Sun, Pioneer 10 was targeted to follow the planet Jupiter in nearly the equatorial plane of the planet. Pioneer 11 was targeted to lead the planet Jupiter in a more nearly polar trajectory. The closest approach for Pioneer 10 was at 2. 86 Jupiter radii (203, 250 km) from the center of the planet. Pioneer 11 had a closest approach of only 1. 6 Jupiter radii (113, 000 km) from the center of the planet. That is only 0. 6 Jupiter radii from the visible surface of the planet. (Note that Fig. 12 does not directly show the radius of closest approach to the planet, but rather where the spacecraft trajectory intersects a plane perpendicular to the hyperbolic approach velocity of the spacecraft.)

There was considerable concern prior to Pioneer 10 Jupiter encounter as to whether the spacecraft could survive the high level of radiation that might be present around the planet Jupiter. It appeared from the Pioneer 10 experience that Pioneer 10 had received about the maximum dosage of radiation possible without sustaining severe damage to the spacecraft. The minor damage that was experienced by Pioneer 10 was mostly of a temporary

nature. A natural question to ask is how could Pioneer 11 be sent 1.2 Jupiter radii closer than Pioneer 10 and be expected to survive. There are two principal factors which made the Pioneer 11 trajectory such that the total dosage of radiation experienced by Pioneer 11 was about the same as Pioneer 10. First, Pioneer 11, because of its closer approach, flew by the planet much faster. The second, and more important, factor was that the radiation around the planet Jupiter was determined by Pioneer 10 to be latitude-dependent and to peak in a disk about the equator of the planet. Because Pioneer 11 went to a lower latitude than Pioneer 10, it crossed the region of peak radiation at a farther distance from the planet.

A potential concern for the DSN in the closer approach to Jupiter of Pioneer 11 was the peak doppler offset and rates that were to be experienced. Fortunately, the Saturn targeting was such that the peak doppler amplitude and rates occurred during the Jupiter Earth occultation. Therefore, the rates that were experienced during the Pioneer 11 encounter were of the same order as those of Pioneer 10.

The Pioneer 10 and 11 Jupiter encounter trajectories can be compared in Figs. 13 and 14, which are drawn relative to Jupiter.

Figure 15 depicts the Pioneer 10 and 11 heliocentric trajectories. Note that the Pioneer 11 spacecraft actually gets closer to the Earth again (to about 3 AU) on its way to Saturn after the Jupiter encounter. Also note that the spacecraft goes between 1 and 1-1/2 AU, or nearly 15 deg, out of the ecliptic plane in transit to Saturn, and that Saturn is very near solar conjunction at the time of Saturn encounter of Pioneer 11. At the time of closest approach of Pioneer 11 to Saturn, the spacecraft will be only 6 deg from the Earth-Sun line. This means that very little post-Saturn encounter data will be returned. The details of the Saturn flyby had not yet been determined at the time of writing; however, there has been discussions of trying to target Pioneer 11 to thread one of the gaps in the Saturn rings.

Table 1. Pioneer 10 and 11 experiments and cognizant experiment team facilities

Magnetometer	Jet Propulsion Laboratory
Plasma analyzer	Ames Research Center
Charged particle detector	University of Chicago
Geiger tube telescope	University of Iowa
Cosmic ray telescope	Goddard Space Flight Center
Trapped radiation detector	University of California, San Diego
Ultraviolet photometer	University of Southern California
Imaging photopolarimeter	University of Arizona
Infrared radiometer	California Institute of Technology
Asteriod meteoroid detector	General Electric
Meteoroid detector	Lewis Research Center
*S-band occultation	Jet Propulsion Laboratory
*Celestial mechanics	Jet Propulsion Laboratory
**Dual fluxgate magnetometer	Goddard Space Flight Center

*Earth-based.

**Additional on Pioneer 11 only.

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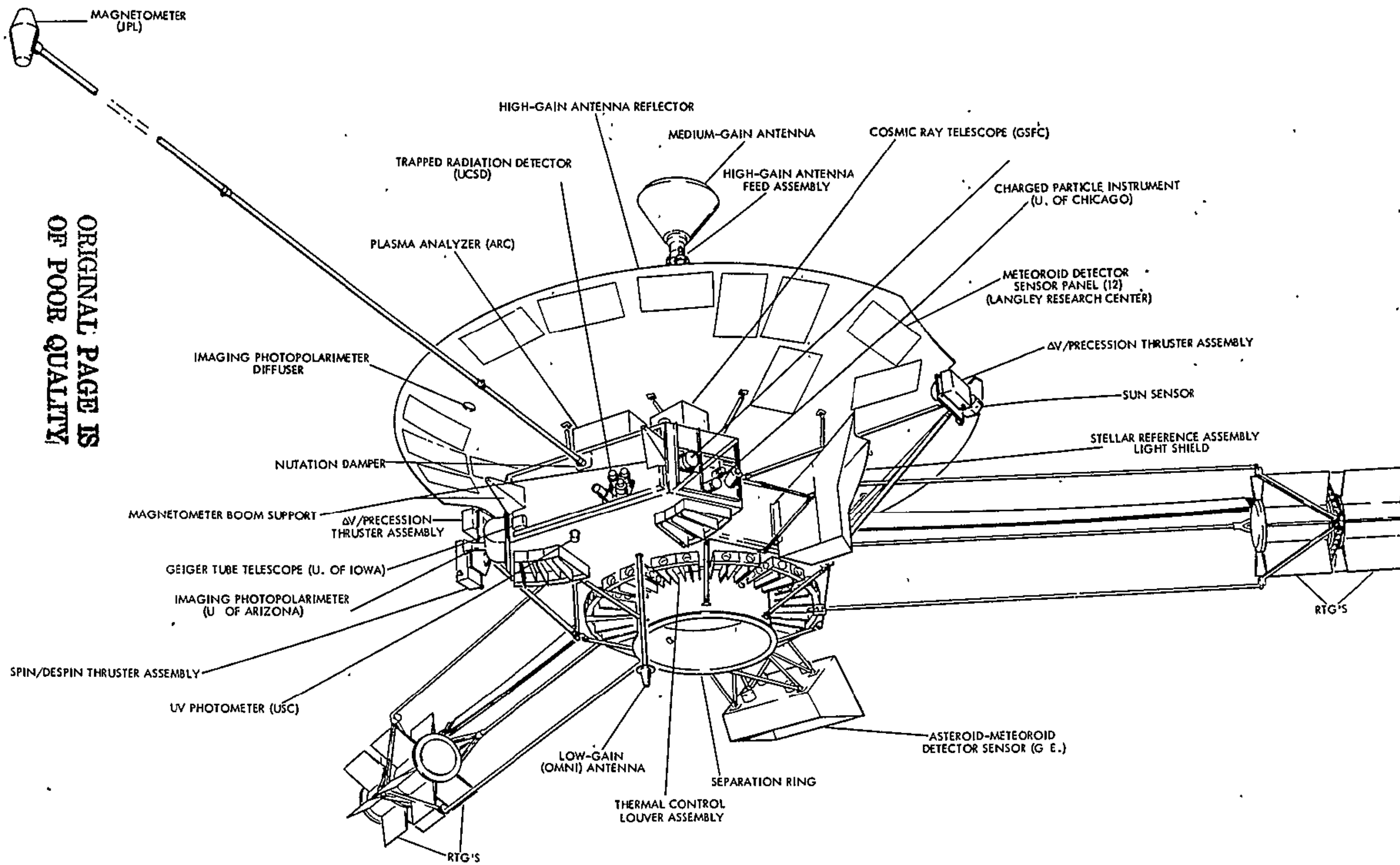


Fig. 11. Pioneer 10 and 11 spacecraft

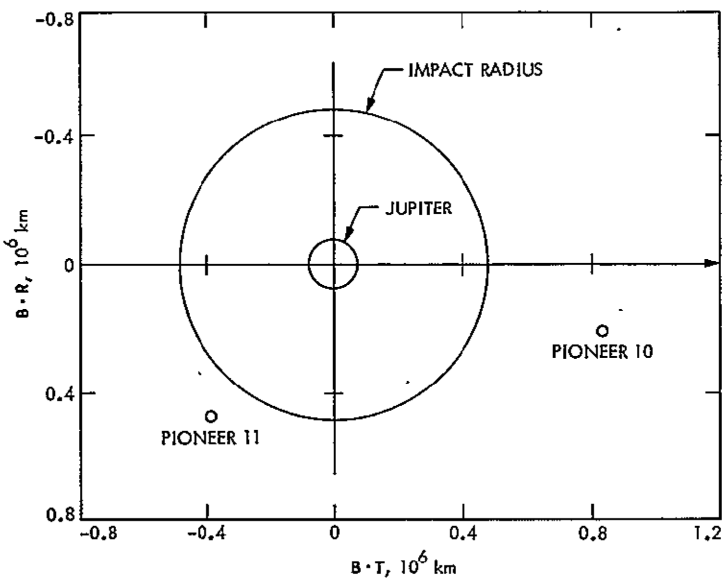


Fig. 12. Pioneer 10 and 11 targeting at Jupiter

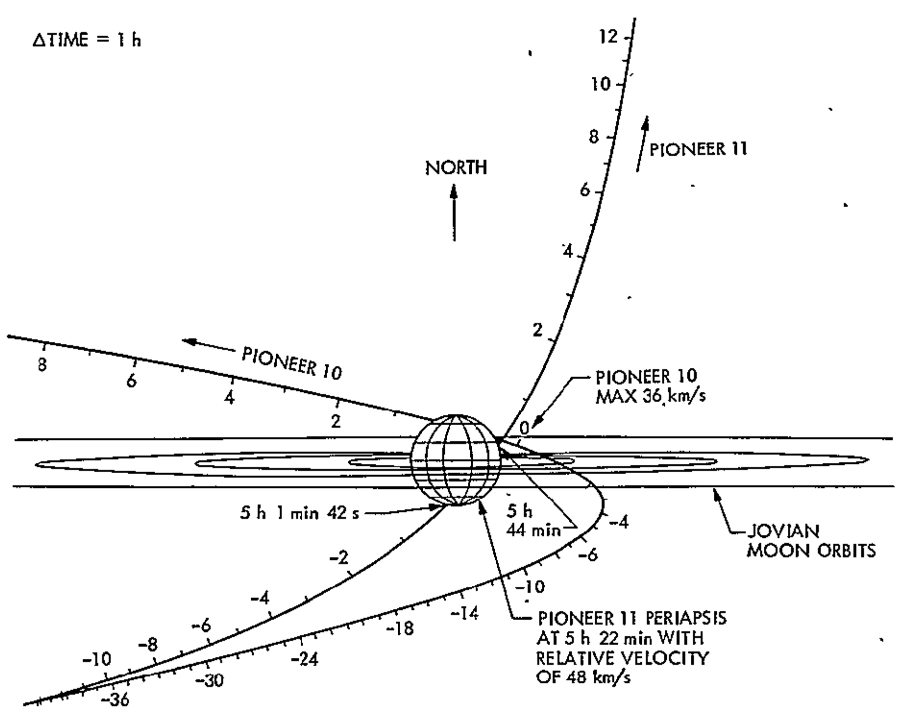


Fig. 13. Pioneer 10 and 11 Jupiter encounter (view from Earth)

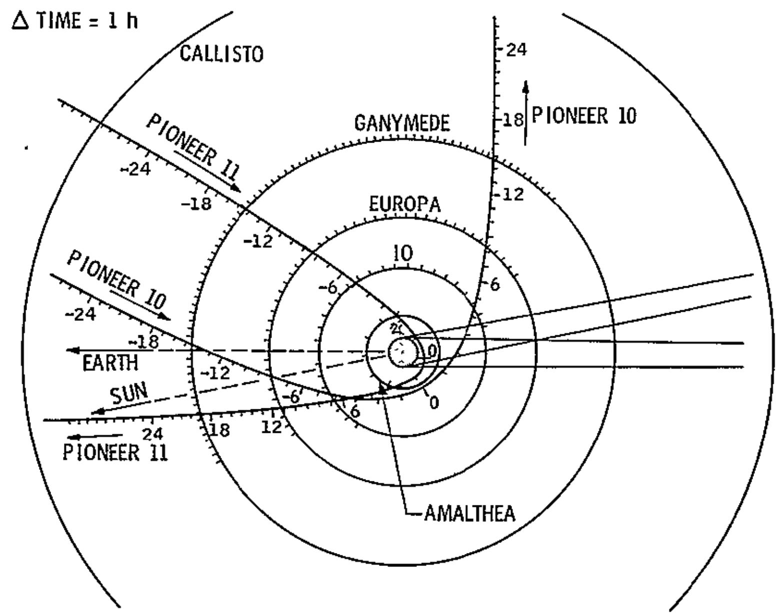


Fig. 14. Pioneer 10 and 11 Jupiter encounter (view from celestial north pole)

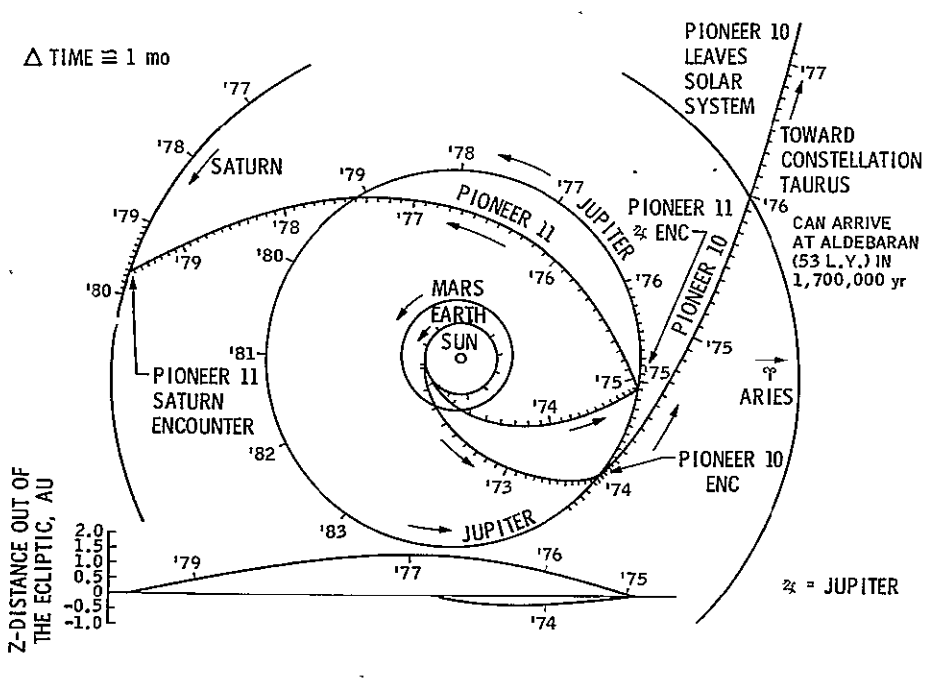


Fig. 15. Pioneer 10 and 11 heliocentric trajectories

IV. DSN SUPPORT PLANNING, PREPARATION, AND EXECUTION OF PIONEER 11 JUPITER ENCOUNTER

A. INTRODUCTION

1. General

After the success of Pioneer 10 Jupiter encounter, it was agreed with the Pioneer Project that Pioneer 11 Jupiter encounter should be supported in as identical a fashion as practical. There was, therefore, no new implementation required for the Pioneer 11 encounter. However, there were some changes necessitated in the Deep Space Network between the Pioneer 10 and 11 encounters, which are described below.

The successful realtime command and control of Pioneer 10 at distances unique to the DSN and the spacecraft's survival through the "prophesied perils" in Jupiter's environment made it feasible to target Pioneer 11 for a closer encounter in a trajectory which would carry the spacecraft to the first encounter with the planet Saturn in 1979.

2. Support Implementation

a. Network Configuration. A 64-m-diameter antenna station, DSS 63, and a 26-m station, DSS 44, were added to the DSN capability during the period of this report. DSS 44 (Australia) became operational in May 1973 and DSS 63 (Spain) in September 1973. DSS 44 was formerly a Satellite Tracking and Data Network Station managed by the Goddard Space Flight Center. DSS 63 was the second 64-m station activated during the life of Pioneer 11 as DSS 43 (Australia) had been activated in April, the month of the spacecraft's launch. DSS 51 (South Africa), a 26-m station, was decommissioned as of June 30, 1974. Table 2 lists the tracking and data acquisition stations that made up the DSN at the end of this document's report period.

b. Elevation Gear Box Problem. During Pioneer 10 encounter, a problem was discovered with the elevation drive motor gear boxes at DSS 43. The symptom was an extremely noisy operation of the boxes. It was seriously debated at that time whether or not the antenna should be taken off-line

during the 60-day encounter period in order to investigate the problem. Instead, to avoid impact on the encounter, it was decided to continue to operate the antenna until after encounter, and emergency procedures were given to the station with instructions on how to cut the shaft on a particular motor if it should happen to freeze up during the encounter. Rework of the elevation drive motor gear boxes was then accomplished at DSS 43 in January and finished in July 1974.

Similar symptoms were also discovered in DSS 63 elevation gear boxes. A meeting was held in late November with Network Operations, the Cognizant Operations Engineer (COE), and the Cognizant Sustaining Engineer (CSE) to assess the risk to Pioneer 11 encounter if the elevation drive motor gear boxes at DSS 63 were not opened up and repaired. It was decided at that time that, even though it was undesirable to have DSS 63 out of service the month before the actual encounter, the risk was unacceptable to the encounter if the work was not accomplished. DSS 63 was taken off-line for the entire month of October so that the remaining elevation drive motor gear boxes could be removed and reworked.

c. Command Confirmation. One of the major activities in preparation for Pioneer 10 encounter was seeking means of providing the most reliable Command System possible for the encounter period. One part of that effort was an attempt to get command confirmation external to the command modulator assembly operational prior to Pioneer 10 encounter. Technical difficulties were encountered in the external command confirmation related to phase stability problems in the configuration loop. For that reason, the external confirmation was not put into operation for Pioneer 10, and, instead, a special cable audit was performed on all cables in the command critical path in which the cables were inspected and sealed prior to Pioneer 10 encounter. Subsequently, the external command confirmation problems were solved, and the external command confirmation, which involves feedback from the exciter to the command modulator assembly, was put into operation on September 1, 1974; therefore, no special cable audit was performed for Pioneer 11 encounter.

d. Transmitter Power. Before the Pioneer 10 Jupiter encounter, there were serious reliability problems with the 400-kW transmitter at DSS 14. Because of reliability concerns, a 100-kW transmitter was installed

at DSS 14 prior to Pioneer 10 encounter. Subsequent to the encounter, the 400-kW transmitter was returned to the vendor and reworked. It was reinstalled at DSS 14 in September 1974. Testing showed the reworked 400-kW transmitter to be considerably improved in reliability; therefore, the 400- instead of the 100-kW transmitter served as the emergency transmitting capability for the Pioneer 11 Jupiter encounter.

e. Feed Cone Changes. In order to prepare for the Viking mission and to support a Saturn radar experiment in December 1974, it was necessary to replace all of the feed cones at DSS 14. The feed cone used for the Pioneer 10 encounter was a prototype, the polarization diversity S-band (PDS) cone. This cone was replaced in September 1974 with the standard S-band polarization diversity (SPD) cone, which was more nearly identical to the operational cones at DSSs 43 and 63. After temporary installation of the X-band receive only (XRO) cone for the purposes of fitting the associated dichroic plate and ellipsoid required for Viking X/S-band, the XRO cone was removed and the S-band megawatt transmit (SMT) cone reinstalled so that Pioneer would have a backup S-band capability in the event of a failure in the newly installed SPD cone.

f. Noise Spikes. The most significant non-command problem experienced by the DSN with Pioneer 11 was noise at DSSs 63 and 43 a few weeks prior to the periapsis passage. The problem at both stations is referred to as "noise spikes," which is the term used for an increase in receiver noise due to some kind of return of the transmitted energy. The usual realtime solution of the problem is to reduce the transmitter power and, therefore, the power of the returned noise. This workaround was acceptable during Pioneer far encounter because of the large uplink margin that the spacecraft enjoys even at the Jupiter distance. This problem was, however, a concern for the near-encounter period when possible radiation effects on the spacecraft could require high transmitter power.

Noise spikes can be caused either by problems internal to the microwave system or by external reflections or arcing on the actual antenna structure. Fortunately, the DSN was able to reduce the problem to an acceptable level before near encounter. The problem at DSS 43 was isolated to a section of waveguide, which was replaced. The corresponding section of

waveguide had been replaced at DSS 43 previously due to noise spiking problems. (As a consequence, a structural design change is in process for this section of waveguide.) The noise-spiking problem at DSS 63 was reduced to an acceptable level by removing the dichroic plate and ellipsoid from the top of the cones. There were no noise-spiking problems during the rest of the encounter after the above action was taken.

g. Software. The only change in telemetry or command software at the Deep Space Stations between the Pioneer 10 and 11 encounters was required in order to accommodate a change in equipment numbering at the conjoint stations, DSSs 42 and 61. This software change involved using a paper-tape overfill whenever loading the Telemetry and Command Processor (TCP) software for Pioneer support at DSSs 42 and 61.

h. Configuration Freeze. The configuration control and freeze plan for Pioneer 11 encounter was essentially identical to that for Pioneer 10, with the dates adjusted to match the change in the time of encounter. A modified configuration control was put into effect from October 29 (the date of the operational readiness test for the encounter) through January 3, 1975. This modified configuration control involves approval by the DSN Managers, Network Operations Project Engineers, and station directors of any Engineering Change Order (ECO) work to be continued during the encounter period. The configuration of the 64-m stations was frozen from November 26 through December 9, which coincided with the 24-h critical operations.

B. NETWORK MANAGEMENT CONTROL AND DOCUMENTATION

1. Planning Meetings

With no new major implementations, and a successful encounter experienced, there was no need for special boards or small working groups as had been the case with Pioneer 10. As a result, planning meetings were less extensive and frequent. The Pioneer Project Support and DSN Managers continued their close coordinative interfacing with the personnel that comprised the normal Pioneer Support Team. Their monthly planning meetings began in mid-year and ran through September. Weekly meetings began in September and accelerated to daily meetings in October. The only

other additional planning factors required were those of the Occultation Strategy Planning Team, the results of which are detailed in Subsection D.

2. Documentation

No new documentation was required for Pioneer 11 encounter. The previous encounter document (616-45) simply required updating. However, because the two original basic documents covering configuration and operating procedures for Pioneer 10/11 (616-19 and 616-20) were in process of being updated and combined, it was decided to add the encounter update. This action provided for all facets of configurations and operations in a single reference document. The resultant Network Operations Plan for the Pioneer 10 and 11 (616-52) document also provided for the requirements of the new operational concept of "direct mode" operations for Pioneer 10, and interim/encounter operations for Pioneer 11. Interim and suspense configuration and operations were included in appendix form for easy removal to retain document currency when they were no longer required. See Subsection C for a description of the direct mode concept.

C. DIRECT MODE OPERATIONS

1. General

The basic objective of direct mode operations was to simplify the ground system support for Pioneer operations. See Subsection II-B-2 for a description of the design rationale and configuration of the direct mode compared to the previous Pioneer Project ground data system configuration. ARC planned to start direct mode operations with Pioneer 10 in September 1974 and to go "direct" with Pioneer 11 in mid-January 1975.

The three major factors concerned with assuming the functions formerly supported by MCCC were realtime telemetry processing, generation and control of all command activity, and the development of a Master Data Record (MDR) generation capability.

2. Command

The direct command capability would consist of an interface between the PDP-11 at ARC and the TCP at the DSS via the high-speed data (HSD)

lines to accomplish command operations. New procedures were jointly developed by ARC and the DSN for command operations.

3. Telemetry

Insofar as the DSN is concerned, no significant differences exist between the telemetry routed directly to ARC by HSD lines and that which is routed to the MCCC. Thus, no discrete DSN procedures were required for direct mode operations. There was a marked difference, however, regarding the data monitoring capability of the Network Operations Control Team (NOCT) and the Network Analysis Team (NAT) at JPL. Data formats previously provided by MCCC on digital television monitors in the NAT and NOCT areas were no longer available. Realtime visibility to telemetry data was temporarily lost, except for HSD block dumps, until further phases of the NCS project were completed. New procedures had to be implemented for NOCT/NAT to monitor data quality and data mode change warnings, and PMOCC operations personnel were impressed with the necessity to keep NOCT advised of data quality problems. In late 1974, limited data visibility was afforded with the implementation of the Network Data Processing (NDP) Block II capability. Complete data visibility is expected in the latter part of 1975 when the NDP Block III capability is implemented. NDP at that time will have the capability of generating an Intermediate Data Record (IDR). The IDR, which is a mirror image of the DSS Digital Original Data Record (DODR), will be deliverable to ARC.

The direct mode of operations did, in fact, become operational for Pioneer 10 in September 1974. Prior to that time, however, many hours of testing and debugging were accomplished. During the period of testing, realtime telemetry data from the tracking stations were simultaneously routed to both ARC and MCCC. In that manner, no data were lost while the direct operational mode was being developed.

D. PIONEER 11 OCCULTATION PLANNING AND RESULTS (Ref. 1)

1. Introduction

On December 3, 1974, at 05:21:39.9 GMT (spacecraft time), when the Pioneer 11 spacecraft reached closest approach to the planet Jupiter, the encounter was simultaneously visible to both the Goldstone and Australian

Deep Space Complexes. This allowed prime participation by two 64-m antenna Deep Space Stations — DSSs 14 and 43. Figure 16 presents an overview timeline of the near-encounter period and shows the significant tracking events in ground transmit time, spacecraft time, and ground receive time (all in GMT).

Almost exactly one year earlier, when the Pioneer 10 spacecraft encountered Jupiter, efforts to ensure the success of tracking operations were concentrated in the following three areas:

(1) The occultation of the spacecraft by the Jovian satellite Io shortly before occultation of the spacecraft by Jupiter itself.

(2) The operation of the then only recently implemented digitally controlled oscillators (DCOs).

(3) The complications in occultation strategy caused by the (then novel) very long round-trip light time (RTLT) of approximately 90 min.

The Pioneer 11 encounter, however, was significantly different from the Pioneer 10 encounter in several areas. Foremost among these were the following:

(1) The absence of any Jovian satellite occultations of the Pioneer 11 spacecraft.

(2) The considerably closer approach of the Pioneer 11 spacecraft to Jupiter (as compared to Pioneer 10), resulting in far more dynamic excursions in near-encounter tracking parameters. For instance, one can compare the radius of closest approach (RCA) in kilometers, the near-encounter frequency excursion at DSS 14 (ΔXA, in hertz at voltage-controlled oscillator (VCO) level) and the maximum frequency rate at DSS 14 ($d(XA)/dt$, in Hz/min, at VCO level) as follows:

	Pioneer 10	Pioneer 11
RCA, km	203,260	113,694
ΔXA, Hz at VCO	1500	3200
$d(XA)/dt$, Hz/min	−10.3	−31.2

Figure 17 similarly illustrates the correspondingly large doppler shift (for the expected doppler modes) at enter occultation.

(3) The decision to enter Jupiter occultation in the two-way (coherent) tracking mode for the Pioneer 11 occultation, in contrast to the Pioneer 10 enter occultation, which was performed in the one-way (noncoherent) tracking mode.

In consideration of the above, the preplanning of Pioneer 11 near Jupiter encounter tracking operations was most intensively focused on properly accounting for the very large tracking parameter excursions and the special problems of entering Jupiter occultation in the two-way tracking mode.

Under the following headings the near-encounter tracking operations planning to account for the large tracking parameter excursions and the two-way enter occultation will be detailed and analyzed as to degree of success achieved. Additionally, other areas of critical tracking operations, particularly rapid reacquisition of the uplink and downlink at exit occultation and quality of near-realtime tracking predictions, will be analyzed.

2. Uplink Tuning Strategy

a. Maintenance of Two-Way Lock. As was previously mentioned, one of the prime differences with the Pioneer 10 Jupiter encounter was the decision to have the Pioneer 11 spacecraft enter Jupiter occultation in the two-way mode. This entails a far greater risk than entering occultation in the one-way mode in that if the spacecraft receiver loses lock shortly before enter occultation, the downlink will shift from two-way to one-way (a shift on the order of several thousand hertz at S-band), and precious radio metric data would be lost while the ground receivers attempted to reestablish lock. Even if the ground receivers were able to rapidly reestablish lock, the resultant one-way doppler data would be nearly useless (for radio science purposes) because 10 or more minutes of one-way doppler data are needed to establish the drift pattern of the spacecraft beacon frequency. Finally, a switch from two-way to one-way might very possibly drive the signal out of the open-loop receiver bandwidth, thus losing this radio metric data source also. This problem was particularly appropriate to the period immediately prior to enter occultation, since it was expected that as the signal began passing through the Jovian atmosphere, there would be momentary periods

of signal attenuation which could cause the spacecraft to drop lock. To mitigate this possibility to the greatest extent possible, it was proposed by Dr. A. Kliore, the occultation experimenter, that during the period of ionospheric/atmospheric traversal by the signal, the DCO at DSS 14 be used to ramp the uplink so as to approximate XA (the spacecraft best lock with doppler accounted for). The general strategy would consist of approximating the ionospheric/atmospheric period of signal traversal by a single ramp. Further, it was decided that the scheme would be defined by the following specific conditions.

Let

$TSF_{14}(t)$ = track synthesizer frequency — transmitted uplink frequency, at VCO level

$XA_{14}(t)$ = spacecraft best-lock uplink frequency (corrected for doppler)

Then it would be required that

$$TSF_{14}(t_0) = XA_{14}(t_0)$$

$$\left\{\frac{d}{dt}\,[TSF_{14}]\right\}_{t_0} = \left\{\frac{d}{dt}\,[XA_{14}]\right\}_{t_0}$$

t_0 = top of Jovian atmosphere

The rationale for this ramping strategy would be that if there occurred momentary signal attenuation and subsequent loss of spacecraft receiver lock, the ground transmitted frequency would be at almost exactly best lock (and would continue at best lock, timewise), and hence the spacecraft receiver would be in a position to relock the uplink almost immediately.

Finally, the uplink strategy at DSS 14 was impacted by the extremely large change in the near-encounter doppler frequency, in particular, during the pre-occultation period of the pass. For instance, the total excursion of XA during this period was about 780 Hz at VCO level (75,000 Hz at S-band).

Since it was a Pioneer Project goal to keep the frequency stress at the spacecraft below approximately 250 Hz, considerable additional tuning somewhere in the pass would be required. It was proposed by the Network Operations Analysis Group (NOAG) that the same ramp necessary during the ionospheric/atmospheric traversal period be utilized by starting it at an earlier time so that the maximum stress at the spacecraft would be constrained to approximately 250 Hz, or by starting the ramp approximately 9 min earlier. This suggestion would have the effect of simplifying overall tracking operations during the pre-occultation period since a single ramp would be easier to implement, and less risky. The suggestion was accepted by the Pioneer 11 Occultation Planning Group; the total uplink strategy at DSS 14 is shown in Figs. 18 and 19.

The final parameter values selected for use at DSS 14 were as follows:

Ramp start time	04:01:53 GMT
Ramp stop time	04:26:53 GMT
Starting frequency	21.988600 MHz (VCO)
Frequency rate	-0.5200 Hz/s (VCO)

b. DSS 43 Uplink Acquisition After Exit Occultation. Although the spacecraft would (nominally) be commanded noncoherent for the first 10 to 15 min following exit occultation, it was concluded by the Pioneer Project that it would be expedient to acquire the uplink as soon as possible after exit occultation so as to gain command capability, if desired. To facilitate this decision, the following strategy was implemented:

(1) DSS 43 transmitter on before exit.

(2) Uplink sweep to begin approximately 3 min following exit occultation.

(3) Sweep parameters to be chosen to yield a total sweep of approximately $XA + 60$ Hz to $XA - 100$ Hz, and a sweep rate relative to the spacecraft of approximately -30 Hz/min at VCO level.

The acquisition parameters finally selected in accordance with the above guidelines are as follows:

Ramp start time	05:06:00	GMT
Ramp stop time	05:11:00	GMT
Starting frequency	21.986360	MHz (VCO)
Frequency rate	− 1.0000	Hz/s (VCO)

This scheme contained three crossings of *XA* by the transmitter frequency, and hence three separate chances of uplink acquisition, the first to occur within a minute of exit. The above uplink strategy is shown in Fig. 20.

3. Ground Receiver Strategy

a. Maintenance of Ground Receiver Lock. For the enter occultation period, it was concluded that ramping the ground receivers according to the same logic as the exciter (except, of course, increasing the times by one RTLT and adjusting the frequencies and frequency rates to account for the differences between the transmitter and receiver frequency levels) would accomplish the identical goal of having the ground receivers at their best-lock frequencies in case of momentary losses of lock.

The ground receiver ramp parameters selected were:

Ramp start time	05:23:16	GMT
Ramp stop time	05:48:16	GMT
DSS 14 starting frequency	49.052579	MHz (DCO)
DSS 43 starting frequency	49.053106	MHz (DCO)
Frequency (DSSs 14 and 43) rate	+1.6941	Hz/s (DCO)

It was subsequently assessed in near realtime that the relative rate between the ground receivers and the downlink frequency at the start of the above ramp would result in an uncomfortably large dynamic phase error ($\Delta\theta$) of approximately 20 deg plus a static phase error (SPE) of approximately 4 deg, in the desired configuration of narrow (12 Hz) tracking loop filter. To correct this possible problem area, a second receiver ramp was added which partially replaced the original ramp (above), so that the final ground receiver ramp strategy was as follows:

First ramp start time	05:05:00	GMT
DSS 14 starting frequency	49.051763	MHz (DCO)
DSS 43 starting frequency	49.052290	MHz (DCO)
Frequency (DSSs 14 and 43) rate	+1.0000	Hz/s (DCO)
Second ramp start time	05:30:00	GMT
Frequency (DSSs 14 and 43) rate	+1.6941	Hz/s (DCO)
Ramp stop time	05:48:16	GMT

Figure 21 shows the predicted DSS 14 ground receiver best-lock frequency versus the above ramp strategy, while Fig. 22 shows the DSS 14 downlink frequency rate versus the above ramp (rate) strategy.

b. Acquisition of Downlink at Exit Occultation. Over the past year and, in particular, during several planetary exit occultations, the DCOs have proved themselves with increasingly excellent results as a new advance in the rapid acquisition of a signal whose frequency and time of appearance are both subject to large uncertainties. The applicable mode of operation for this type of acquisition is the acquisition mode (ACQ MODE), in which a triangular frequency sweep is initiated at a fixed sweep rate and between prestored upper and lower frequency limits. After testing to determine a reasonable sweep rate (i.e., the highest sweep rate possessing an extremely high probability of acquisition) and consideration of (Pioneer Project Navigation-supplied) orbital uncertainties, the following DCO acquisition mode parameters for DSS 14 and 43 ground receivers were selected:

DCO sweep rate	±1000 Hz/s (S-band)
DCO sweep excursion about the exit occultation point	±5000 Hz (S-band)

These sweep patterns can be seen in Figs. 23 and 24 for DSSs 14 and 43, respectively.

4. Post-Encounter Analysis

The previous parts of Subsection D have dealt with the Jovian encounter planning as it pertained to tracking operations. Procedures such as uplink

tuning for the minimization of spacecraft phase error, ground receiver tuning for minimization of ground station phase error, and DCO ACQ MODE usage for downlink acquisition(s) at exit occultation were discussed, and the final plans for the various phases of the operations were outlined.

Now, the degree of success of the various operations will be described based on post-encounter analysis of the returned radio metric data.

a. DSS 14 Maintenance of Uplink During Enter Occultation. As mentioned previously, an uplink ramp of 25-min duration and at a rate of approximately 50 Hz/s at S-band was executed by DSS 14 so as to maintain the maximum spacecraft receiver static phase error below 25,000 Hz at S-band and to substantially eliminate both the dynamic and the static phase error at the time of traversal of the top of the Jovian atmosphere. The success of this effort can be judged only indirectly, as there is no way of knowing what might have occurred had not the uplink tuning been performed. However, considering that the uplink was maintained throughout the time up until the loss of lock by the closed-loop ground receivers, and in fact up until the time of loss of lock by the open-loop ground receivers, the uplink tuning must be gauged as a complete success.

b. Downlink Maintenance by (Closed Loop) Receivers at DSSs 14 and 43 During Enter Occultation. As previously described, both DSSs 14 and 43 executed two receiver ramps during the enter-occultation period with a purpose similar to the uplink ramp performed by DSS 14—to substantially eliminate the static and dynamic phase error for the ground receivers at the time of traversal of the top of the Jovian atmosphere. The closed-loop receivers at DSSs 14 and 43 dropped lock at the following times:

DSS 14	05:41:48 GMT
DSS 43	05:41:49 GMT

Both of the above times can be considered favorably when compared to the loss of lock by the DSS 43 open-loop receiver at 05:42:05 GMT (as supplied by Dr. Kliore), or only 16 to 17 s later. Figure 25 shows the closed-loop doppler data for both DSSs 14 and 43 immediately prior to and subsequent to the loss of lock. Although receiver ramps cannot be seen in

the doppler data, the following observations, which tend to support both the accuracy of and the rationale for the ground receiver ramps, can be made:

(1) The closed-loop receivers maintained continuous lock throughout the high-frequency rate portion of the enter-occultation period, and the dropped lock times of 05:41:48 and 05:41:49 would indicate a substantial signal entry into the atmosphere before loss of lock.

(2) The large fluctuations seen in the closed-loop doppler data (Fig. 25) in the 30 s before loss of lock would seem to indicate that had the ground receivers not been close to the best-lock frequency and best-lock frequency rate, they might easily have been knocked out of lock.

(3) After loss of lock, the receiver frequency (which is then directly reflected in the doppler data) can be seen in Fig. 25 to agree very closely with the predicted receiver frequency—thus indicating the ramp was correctly computed and implemented by the DSS.

Finally, it should be noted that the various tuning schemes did not take into account refraction by the Jovian atmosphere, and had it been possible to accurately predict and factor the Jovian atmosphere refraction into the tuning schemes, even better results might possibly have been obtained.

c. <u>DSS 14 and 43 Downlink Acquisition at Exit Occultation.</u> As mentioned earlier, the use of the DCOs in the acquisition mode has produced excellent results in recent planetary occultations; the Pioneer 11 exit occultation has proved to be no exception to these results. Figures 23 and 24 show the actual receiver sweep patterns executed by DSSs 14 and 43, respectively. Using the open-loop receiver lockup times (indicated in Figs. 23 and 24) as the time of signal appearance, it can be seen from Fig. 24 that DSS 43 locked to the emergent signal on the first crossing through the received frequency (at 06:24:21 GMT), while in Fig. 23 it can be seen that DSS 14 locked to the emergent signal on the second crossing through the received frequency (at 06:24:41 GMT).

d. <u>Acquisition of DSS 43 Uplink After Exit Occultation.</u> Since the uplink acquisition sweep was performed by DSS 43 at a time when the spacecraft had been previously commanded noncoherent, it was not possible to

pinpoint the exact time of uplink acquisition by extrapolating backward from the time of downlink mode change (from one-way to two- or three-way) by one RTLT, as might normally be done. All that can be said is that the uplink acquisition was routinely successful, as evidenced by the fact that the subsequent command to the spacecraft to return to coherent operations some minutes later was successfully received and executed.

e. DSS 14 and 43 Acquisition of Post-Occultation Two-Way Downlink. In response to the post-occultation command to the spacecraft to return to the coherent mode, both DSSs 43 and 14 dropped lock at 06:41:02 GMT, at which time the downlink had shifted from one-way to two-way and three-way, respectively. Within about 2 min DSS 43 reacquired the downlink and confirmed two-way. However, DSS 14 required several additional minutes to reacquire. A study of the DSS 14 doppler data, as seen in Fig. 26, discloses that the station was searching for the two-way downlink instead of the actual three-way downlink (with DSS 43). This error at the station might have been triggered by a request from the Network Operations Control Team (NOCT) for the stations to flag their data as two-way when the proper request should have been for the stations to flag their data as either two-way or three-way, as appropriate. This slight delay in downlink acquisition by DSS 14 did not impact either the return of scientific (telemetered) data or radio metric data, due to the rapid reacquisition by DSS 43.

5. Prediction Accuracy

In virtually all recent planetary encounters, the various navigation teams have indicated that their orbital solutions will continue to improve right up until the time of encounter. Actual recent experience with both small and large planet encounters, however, suggests that clear-cut orbital accuracy improvement ends somewhere in the time period from encounter minus two days to encounter minus one week. Table 3 presents a list of various tracking parameters of interest during the Pioneer 11 encounter, as a function of the various probe ephemeris tapes (PETs) supplied by the navigation team. Once again a small but steady improvement is noted up until the encounter-minus-two-day PET (Q635) but that the next and final pre-occultation PET at encounter minus six hours (Q639) represents a small net loss in prediction accuracy.

6. Summary of Tracking Operations During Jupiter Encounter

Tracking operations during the near-encounter period proceeded exactly as planned and resulted in a highly successful encounter. The most significant features of this encounter, which distinguished it from the previous Jupiter encounter, were:

(1) The very dynamic excursions in near-encounter tracking parameters.

(2) The two-way entry into occultation.

The pre-occultation planning described here at length would appear to have very successfully incorporated and accounted for the above features.

E. DSN TEST AND TRAINING PLAN

1. Overall Plan and Schedule

The Pioneer 11/Jupiter encounter test and training plan was evolved by joint DSN, MCCC, and Flight Project effort, and was coordinated by the GDS Project Engineer in Section 295 (Space Flight Operations Section).

The Pioneer 11 encounter training totaled 78 h in 6 tests, including the Operational Readiness Test (ORT), compared with the 328 h extended for Pioneer 10 encounter. With no new implementation required, the Pioneer 11 encounter test and training plan was mostly a review of the successful Pioneer 10 encounter of 1973, and therefore a significant reduction in the total test program was felt feasible.

The Pioneer 11 tests were run during actual Pioneer 11 tracks, using the spacecraft as a simulation source in exactly the same fashion as for the Pioneer 10 encounter. Some parts of the tests and the ORT involved the actual commanding of the spacecraft in executing portions of the real encounter sequence.

No significant DSN problems were encountered in any of the tests and training for the Pioneer 11 encounter.

Subsection IV-D reports on the occultation planning and testing.

Table 4 lists significant encounter events.

2. Tests

MOS encounter training tests (Table 5) were designed to exercise the GDS recovery sequences and detailed procedures for various failure modes. These modes involved the DSN, GCF, MCCC, Pioneer Mission Operations Center (PMOC), Pioneer Mission Control Center (PMCC), and PMSA personnel. The prime objective of the training was to cover as many personnel as possible on the various shift assignments. Special emphasis was on the training of Project personnel with the emergency voice command transmission procedures (reference Network Operations Plan 616-52, Table E-11). An additional 0.5 h was scheduled to perform this procedure with all stations on a weekly basis 2 mo prior to the 60-day encounter period.

The Operations Readiness Test (ORT) was conducted, without planned anomalies, to verify the operational readiness of the Mission Operations System (MOS) and to train personnel to support encounter.

With the use of actual tracks, it was necessary to have the stations track with the transmitter in dummy load because some of the failures introduced into the systems in the MOS tests might have damaged the spacecraft.

Particular items that had been of training concern for the Pioneer 10 encounter were the digitally controlled oscillators at DSSs 14 and 43. These devices had replaced the voltage-controlled oscillators and enabled precision tuning of the transmitters and receivers at DSSs 14 and 43 to allow for the tremendous doppler experienced during the Jupiter periapsis passage. However, for Pioneer 11, there had been a year and a half of operational experience with these devices, which were used for all tuning, including handovers of missions tracked at DSSs 14 and 43. For this reason, there was more confidence in successful operational use of these devices for the Pioneer 11 encounter than there was for Pioneer 10. Ranging data accuracy from 1 to 10 km was achieved using the devices to do sawtooth ramping and observing the effects of the ramping a round-trip light time after transmission. Such ramping data was taken once a month and helped achieve the navigational accuracy required for Pioneer 11 to successfully fly past Jupiter and on to Saturn.

The DSN test and training plan outline is detailed in Network Operations Plan for Pioneer 10 and 11, Document 616-52, Paragraph C.

F. DATA RECORD SUPPORT PLANNING

The complex negotiation and planning required to establish a total plan for the previous encounter period, together with "after the fact" experience, made data record support for the Pioneer 11 encounter easier but not trouble-free. The major problem was sharing time in the 360/75. MCCC supported all active missions for real-time data processing and Master Data Record (MDR) generation (except for Pioneer 10 which operated in the direct mode during the second encounter). MCCC was still responsible for the production of Pioneer MDRs as well, which were compiled from a combination of data received in realtime and data recalled from the tracking station to fill realtime gaps. Recall software programs had not yet been perfected, and recall time was at a premium for both MCCC and the tracking stations. As a result, MDR generation began to backlog significantly.

The solution to the problem resulted in extending the time period, beyond that which was originally agreed upon, whereby the encounter stations shipped the Digital Original Data Records (DODRs) to JPL for off-line MDR processing. In this manner, MCCC/station time conflicts were virtually eliminated and MDR generation was expedited because of the greater flexibility of off-line processing.

G. NASCOM AND GROUND COMMUNICATIONS FACILITY PLANNING

1. <u>NASCOM Network Coverage Requirements</u>

The DSN requested that NASCOM provide Network coverage for the entire 60 days of encounter. NASCOM agreed to provide the following NASCOM Network coverage as requested:

(1) Special surveillance from November 3 to December 1 and from December 5 to January 2 for all Deep Space Stations and ARC. Special surveillance consists of the Goddard Space Flight Center Communications Manager transmitting a message requesting that all supporting switching centers pay extra close attention to the circuits in support of the Pioneer mission.

(2) Full NASCOM coverage from 0001Z to 2400Z, December 2 and from 0001Z to 2400Z, December 4 for DSSs 14, 43, and 63 and ARC.

Full NASCOM coverage consists of the designated centers operating emergency power systems, providing dual configuration at switching centers whenever possible, having NASCOM computer programmers and computer engineers on standby, having first-line supervisors on duty during the key periods, and having commercial carriers informally notified of the impending mission requirement and requesting them to provide critical support.

(3) Special coverage from 0001Z to 2400Z, December 3 for DSSs 14, 42, 43, and 63 and ARC.

Special coverage consists of all requirements outlined in special surveillance and full NASCOM coverage plus formal notification of commercial/government and overseas carriers.

2. Goldstone Circuits

Specific actions taken with regard to those portions of the GCF that are the responsibility of JPL were that the commercial carrier involved between Goldstone and JPL was requested to have maintenance personnel in position during the critical mission period. Goldstone communications personnel were augmented by supervisory personnel; GCF switching center schedules were modified to provide increased manning to support the Communications Chief.

H. MISCELLANEOUS ADDITIONAL PREPARATION ACTIVITY

1. Levels of Ground Data System Support

Levels of total GDS support were defined to provide varying degrees of redundancy and resulting speed of recovery as a function of mission requirements. The principal definitions, which applied to both Pioneer Jupiter encounters, were Critical, Special 1, and Special 2.

Critical coverage involved providing every level of redundancy available within the total GDS. It also involved loading backup Telemetry and Command Processing streams at the stations supporting Pioneer 11. The resulting restoration time, based on available on-site redundant equipment, was on the order of 6 min for critical coverage. Special 1

coverage was virtually identical to Special 2 coverage except that higher operator emphasis is placed on the telemetry data than in Special 2 coverage, and the backup TCP is maintained at a higher level of readiness than during Special 2. Maximum restoration time for redundant equipment is 20 min in the case of both Special 1 and Special 2 support. The support periods for the Pioneer 11 encounter were defined as follows: November 3 through 25, Special 1 support was required 8 h per day; November 24 and 25 and December 13 and 14, critical support was provided 8 h per day; during the period November 25 to December 10, critical support was provided 24 h per day; and from December 10 to January 3, Special 1 was provided 8 h per day. Special 2 coverage was provided at all other times during the 60 days.

2. Configuration Control

It was impractical to freeze the 64-m network for the entire 60 days of encounter, particularly because of work necessary to prepare for other mission activities and ECO installations. Instead, the modified configuration control concept, which had been developed for the first encounter, was again implemented.

Modified configuration control was to apply from October 30, the completion of the Operational Readiness Testing, until January 3. Under modified configuration control, approval of the DSN Managers, Network Operations Project Engineers, and station directors would be required before any Engineering Change Order could be implemented at the affected stations. A freeze was imposed at DSSs 43 and 63 from November 23 through December 10. The freeze for DSS 14 was slightly less and covered the time period from November 26 to December 10.

3. Pseudoranging

The pseudoranging concept developed for the Pioneer 10 encounter period using the digitally controlled oscillator (DCO), as described in the Pioneer 10 final report, resulted in an accuracy of 10 km for measuring spacecraft distance from Earth. At that time the DCO was still relatively new, and the ranging concept was in the development stage as well.

From December 1973 through the Pioneer 11 Jupiter encounter, continued use of the DCO ramp ranging provided a much greater confidence in its capabilities and accuracy, and increased sophistication of the

processing of the data. As a consequence, spacecraft distance measurement to an accuracy of 3 km was achieved. Pioneer Project has used the pseudo-ranging data for orbit determination processing.

I. NETWORK ALLOCATION CONFLICTS

1. Imaging Photopolarimeter Requirements

The Pioneer Project planned the Jupiter far-encounter imaging photopolarimeter (IPP) activities over DSS 63 from November 3 through November 25 and from December 10 through January 3. DSS 63 was selected because the station was not committed for Helios support, while there was uncertainty over DSS 14 and 43 requirements in support of the Helios launch, and Step 1 and Step 2 fine maneuvers. IPP near-encounter maneuvers, November 26 through December 9, were supported with continuous 64-m station coverage at a bit rate of 2048 bps. Pioneer Project IPP requirements are shown in Table 6. The operation of the IPP instrument and the resulting extensive coverage requirements are described in Volume III (page 24) of this series of reports.

2. MVM'73 and Helios Conflicts

In the joint project coordination meetings under the auspices of the Operations Support Coordination Office (OSCO), DSN allocation conflicts between flight projects and other users were resolved. During the Pioneer 11 encounter period, the major concern was the uncertainty of the Helios launch date and 64-m requirements for the Step 1 and Step 2 maneuvers. As it turned out, Helios launch and step maneuvers were performed over the 26-m stations. When Helios switched to the high-gain antenna, there appeared to be a problem in Experiment 5 (plasma and radio wave); therefore, to enhance troubleshooting on this problem, Helios Project negotiated with Pioneer Project for a 64-m pass on December 18.

MVM'73 scheduling conflicts were of a lesser concern during the Pioneer 11 encounter period because of the difference in the spacecraft view periods. However, because of Mariner's problems in the Attitude Control System (ACS), the 64-m requirements were increased in order to achieve the orbit determination accuracy required to allow for trajectory correction maneuver 7 in February and for Mercury III encounter in mid-March.

3. Viking Implementation Conflict

The following restrictions were determined to assure the best support of the Viking implementation effort at the 64-m stations without jeopardizing the support of Pioneer 11 encounter. Before any Viking Engineering Change Order (ECO) installations were allowed, prior approval would be required of the DSN Managers and the Network Operations Project Engineers (NOPES) for the Pioneer, Mariner, and Helios Projects. Concurrence also was required of the station director concerned. The Pioneer NOPE, E. Burke, was designated coordinator of actions required to arrive at decisions as to whether or not ECOs would be installed during the period of modified configuration control or deferred until after January 3, 1975. The Viking NOPE would flag, for all three 64-m stations, those ECOs that were considered urgent enough to warrant the risk of installing them during the modified configuration control period. However, no ECOs were installed during the critical period.

Table 2. Tracking and data acquisition stations of the DSN

DSCC	Location	DSS	DSS serial designation	Antenna		Year of initial operation
				Diameter, m (ft)	Type of mounting	
Goldstone	California	Pioneer	11	26(85)	Polar	1958
		Echo	12	26(85)	Polar	1962
		(Venus)[a]	13	26(85)	Az-El	1962
		Mars	14	64(210)	Az-El	1966
Tidbinbilla	Australia	Weemala	42	26(85)	Polar	1965
		Ballima	43	64(210)	Az-El	1973
—	Australia	Honeysuckle Creek	44	26(85)	X-Y	1973
Madrid	Spain	Robledo	61	26(85)	Polar	1965
		Cebreros	62	26(85)	Polar	1967
		Rebledo	63	64(210)	Az-El	1973

[a]A maintenance facility. Besides the 26-m (85-ft) diam Az-El mounted antenna, DSS 13 has a 9-m (30-ft) diam Az-El mounted antenna that is used for interstation time correlation using lunar reflection techniques, for testing the design of new equipment, and for support of ground-based radio science.

Table 3. Values for DSS 14

PET	Date received	Enter occultation			Exit occultation	
		XA at 04:20	D2 at 05:40	Time	D1 at 06:30	Time
6544	N/A	8057.7	1567912	05:40:33	1377121	06:25:14
6548	11/13/74	8030.4	1562418	N/A	1369007	N/A
6549	N/A	8028.0	1561945	05:39:35	1368785	06:24:09
6550	11/28/74	8030.5	1562432	05:39:40	1369145	06:24:14
Q631	11/29/74	8033.7	1563055	05:39:46	1369638	06:24:22
Q634	11/30/74	8034.8	1563275	05:39:49	1369820	06:24:24
Q635	12/01/74	8035.2	1563350	05:39:50	1369882	06:24:25
Q639	12/03/74[a]	8033.8	1563072	05:39:47	1369847	06:24:22
From actual data		8036.4	1563590		1370590	

[a]E – 6 h PET

Table 4. Significant encounter events

Event	Time[a]
Start Encounter Period	307/0000
Bow Shock Crossing (earliest)	329/1600
Magnetopause Crossing	330/1600 - 332/0000
Enter Radiation Belts (6 R_J)	336/2321
Enter Solar Occultation	337/0500
Enter Jupiter Occultation	337/0501
Periapsis	337/0521
Exit Solar Occultation	337/0534 (duration 33 min 31 s)
Exit Jupiter Occultation	337/0543 (duration 42 min 02 s)
Exit Radiation Belts (6 R_J)	337/1121
Magnetopause Crossing	342/2000 - 344/0400
Bow Shock Crossing	345/0800
End Encounter Period	003/0000

[a]Times are spacecraft event (SCE) times.

Table 5. Pioneer 11 MOS encounter test and training schedule

Schedule	Date
MOS/GDS Encounter Training Test 1	September 6
MOS/GDS Encounter Training Test 2	September 26
MOS/GDS Encounter Training Test 3	October 8
MOS/GDS Encounter Training Test 4	October 15
MOS/GDS Encounter Training Test 5	October 24
MOS Encounter Operational Readiness Test	October 29
Modified configuration control established for DSSs 14, 43, and 63	October 30
Start encounter period	November 3
Configuration freeze established for DSSs 14, 43, and 63	November 26
Start near-encounter period	November 26
Closest approach	December 3
End near-encounter period	December 9
Configuration freeze removed from DSSs 14, 43, and 63	December 10
End encounter period	January 3
Modified configuration control removed from DSSs 14, 43, and 63	January 3

Table 6. Priority 2 IPP support periods

Date		DOY	Time period, GMT	Activity
Nov.	3	307	1545-2255	IPP observation (Jupiter)
	5	309	1200-0010	IPP observation (Sirius)
	7	311	1530-2240	IPP observation (Jupiter)
	9	313	1525-2235	IPP observation (Jupiter)
	10	314	1520-1725	IPP observation (Solar Diffuser)
	11	315	1515-2225	IPP observation (Jupiter)
	12	316	1510-2220	IPP observation (Jupiter)
	14	318	1505-2215	IPP observation (Jupiter)
	15	319	1500-2210	IPP observation (Jupiter)
	17	321	1450-2200	IPP observation (Jupiter)
	18-25	322-329	TBD	IPP observations
Nov. to Dec.	26 to 9	330 to 343	0000-2400	Near-encounter activities
	10-17	344-351	TBD	IPP observations
	19	353	1250-2000	IPP observation (Jupiter)
	20	354	1245-1745	Precession
	21	355	1240-1950	IPP observation (Jupiter)
	23	357	1235-1945	IPP observation (Jupiter)
	24	358	1130-2340	IPP observation (Sirius)
	25	359	1225-1935	IPP observation (Jupiter)
	27	361	1220-1930	IPP observation (Jupiter)
	28	362	1215-1420	IPP observation (Solar Diffuser)
	29	363	1210-1920	IPP observation (Jupiter)
	31	365	1205-1915	IPP observation (Jupiter)
Jan.	2	002	1155-1905	IPP observation (Jupiter)

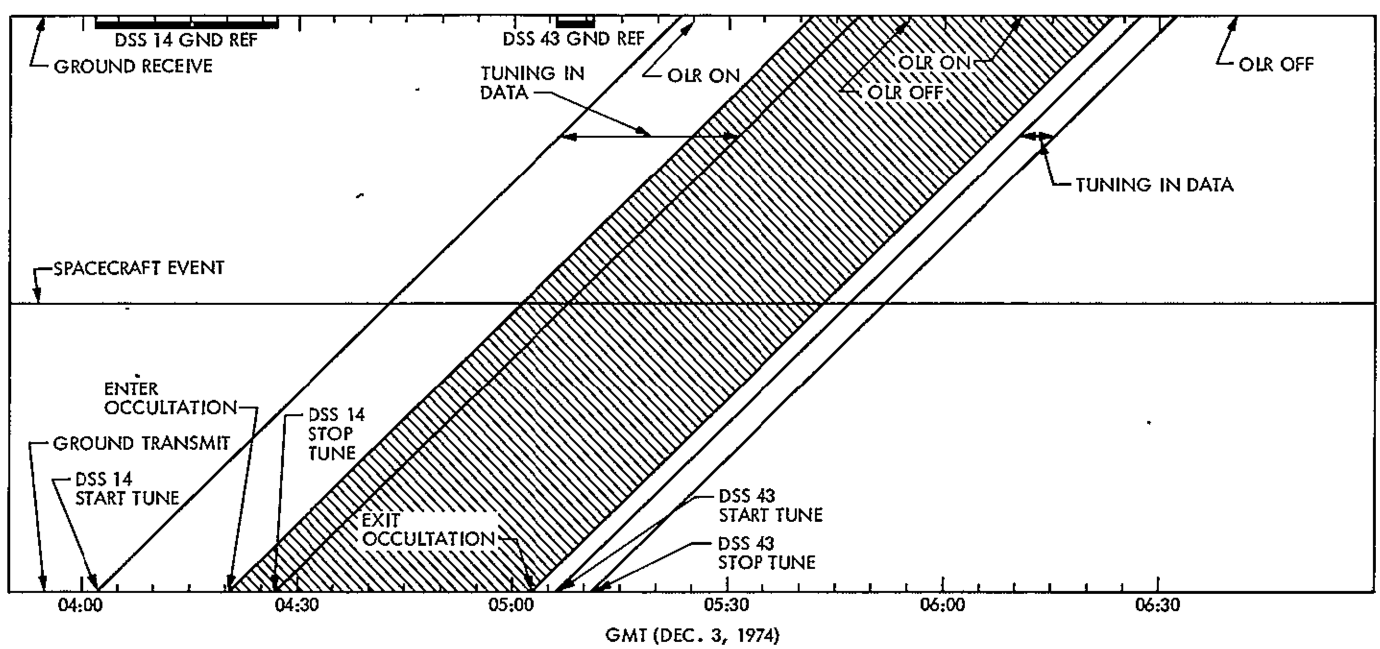


Fig. 16. Pioneer 11 Jupiter encounter

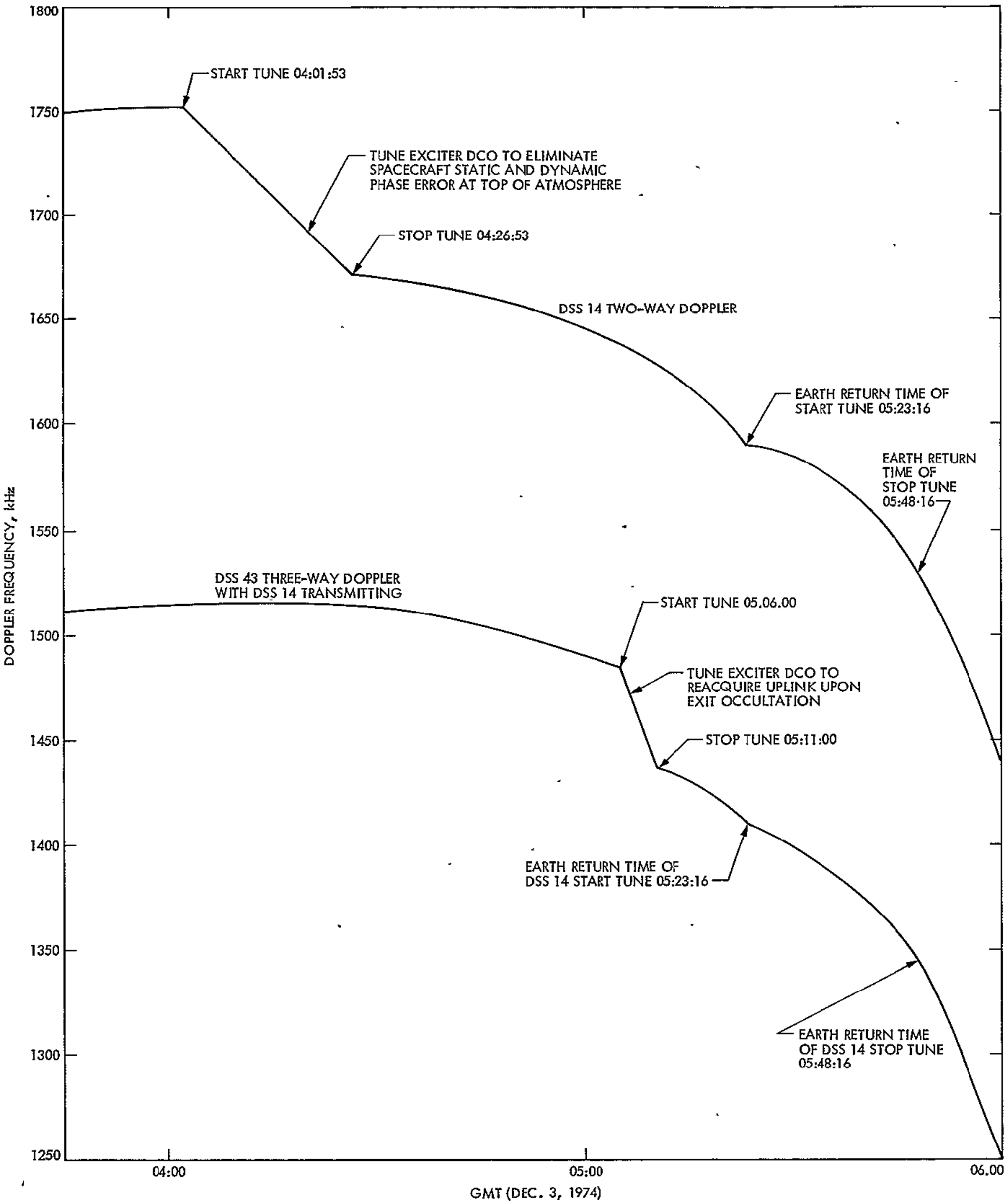


Fig. 17. DSS 14/43 doppler at enter Jupiter occultation

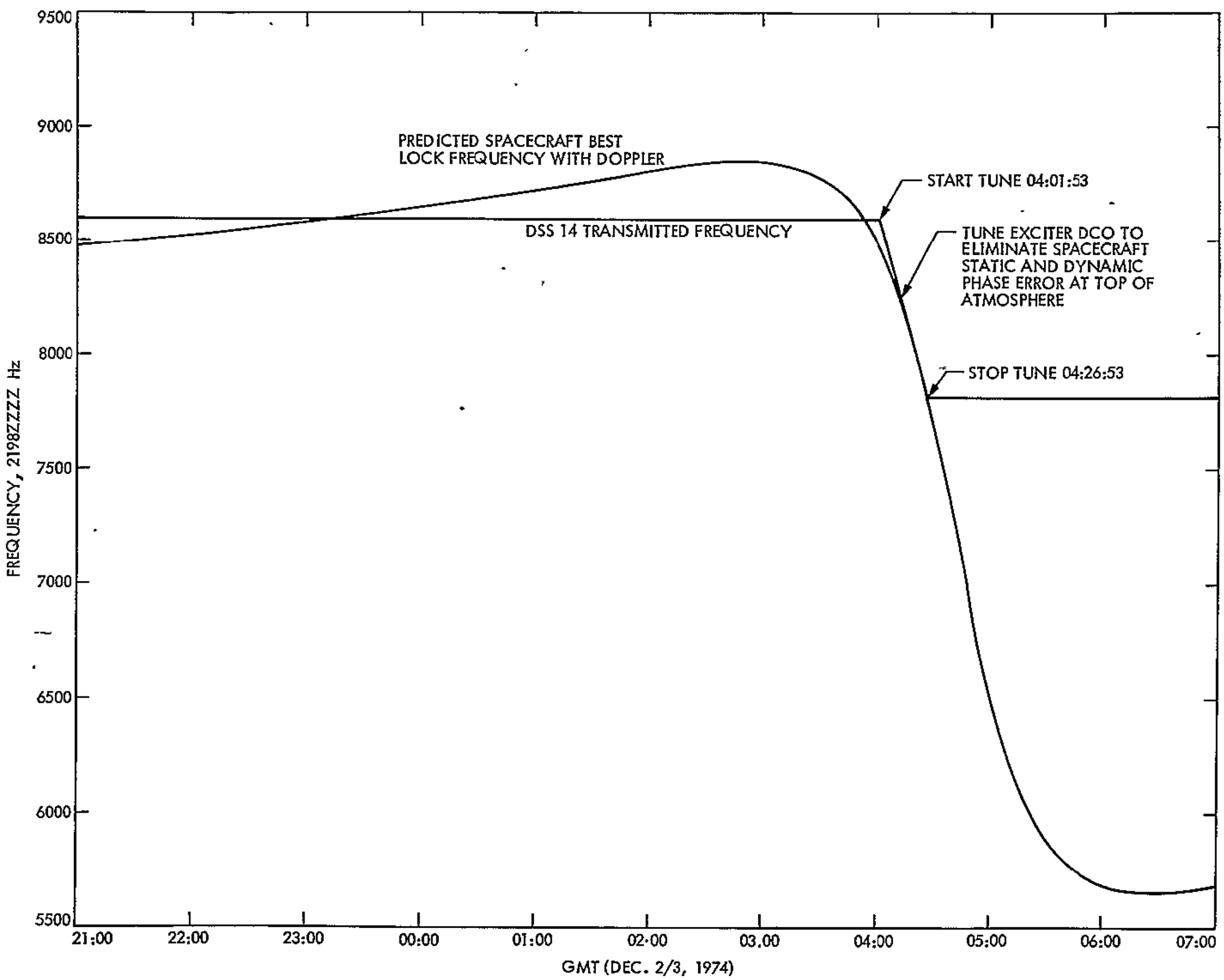


Fig. 18. DSS 14 transmitted frequency pattern

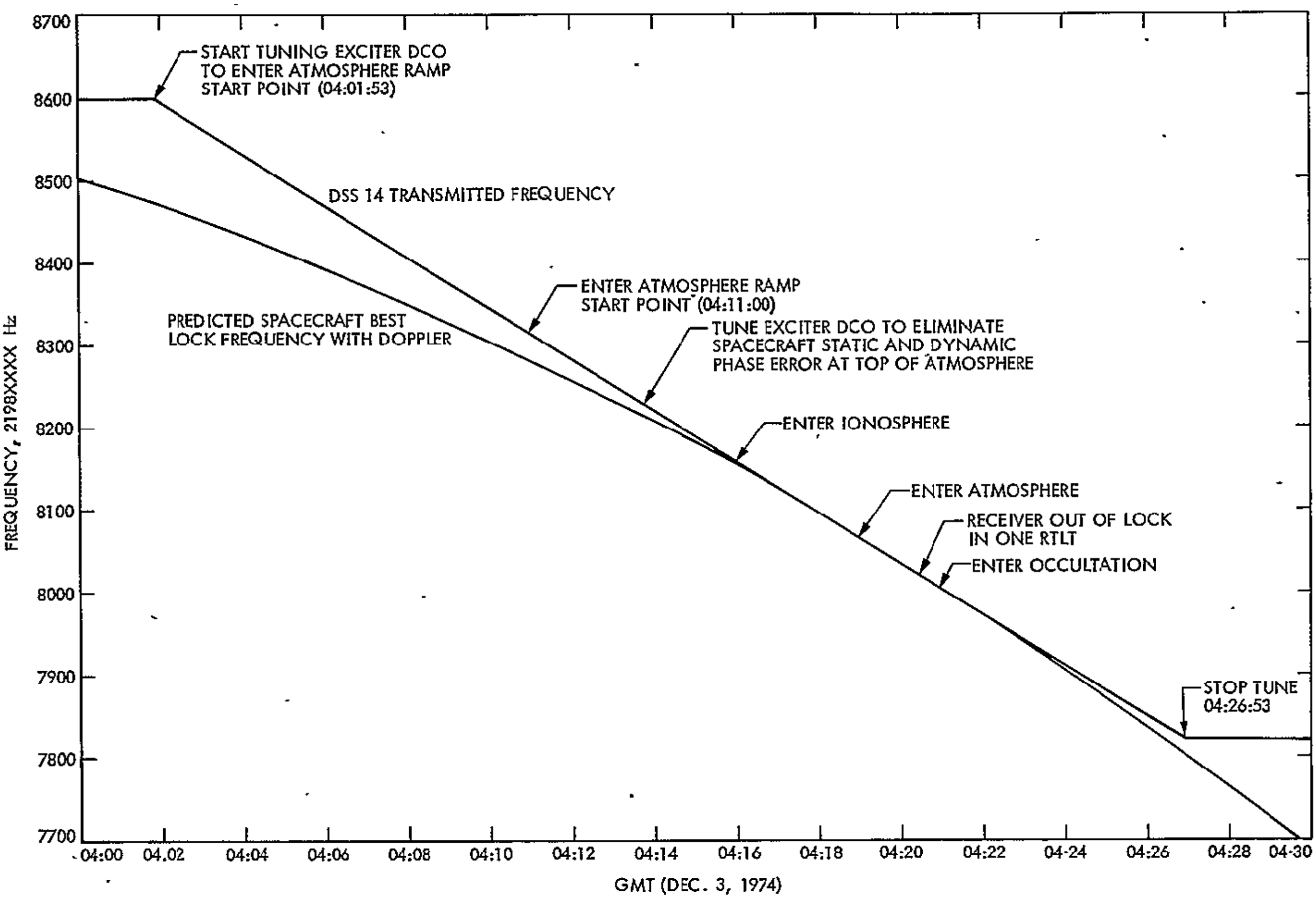


Fig. 19. DSS 14 transmitted frequency pattern at enter Jupiter occultation

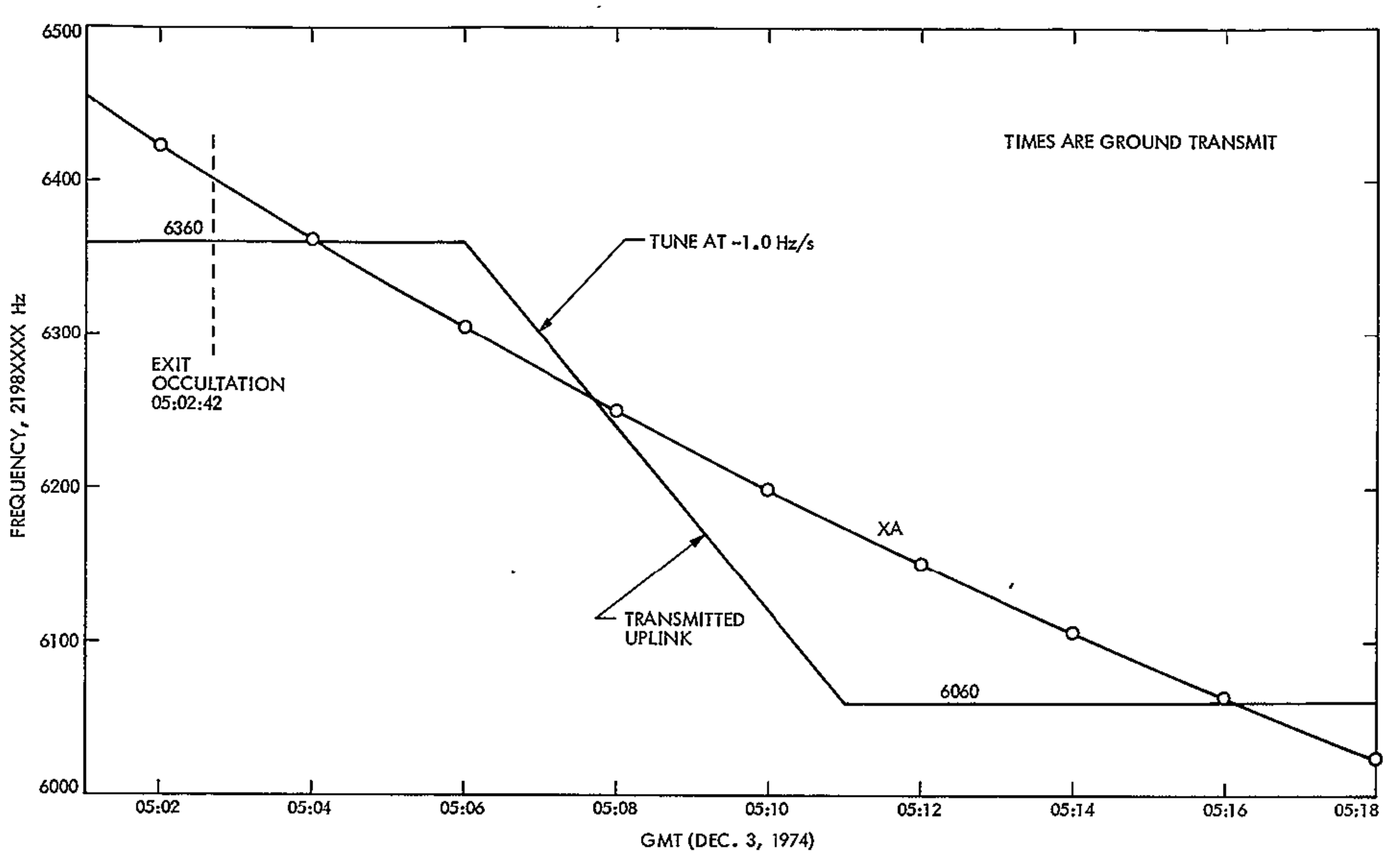


Fig. 20. Sweep pattern to acquire uplink after exit occultation at DSS 43

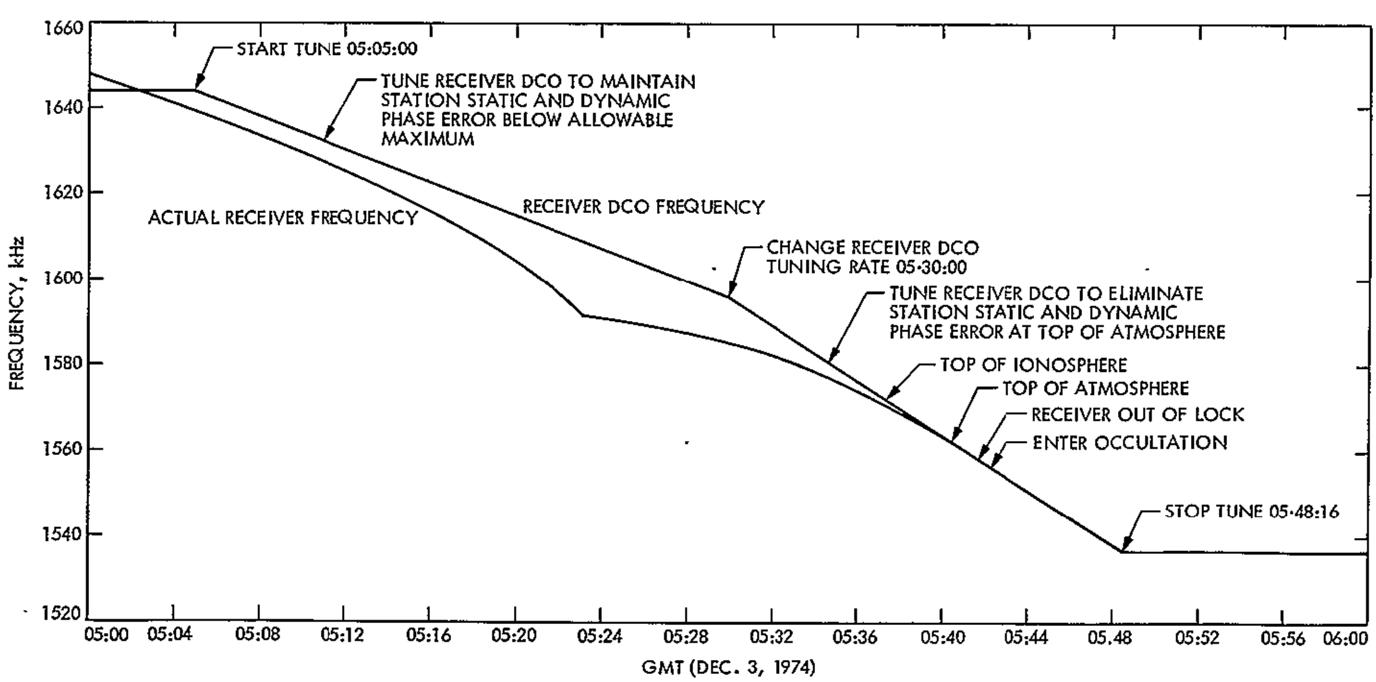


Fig. 21. DSS 14 two-way doppler at enter Jupiter occultation

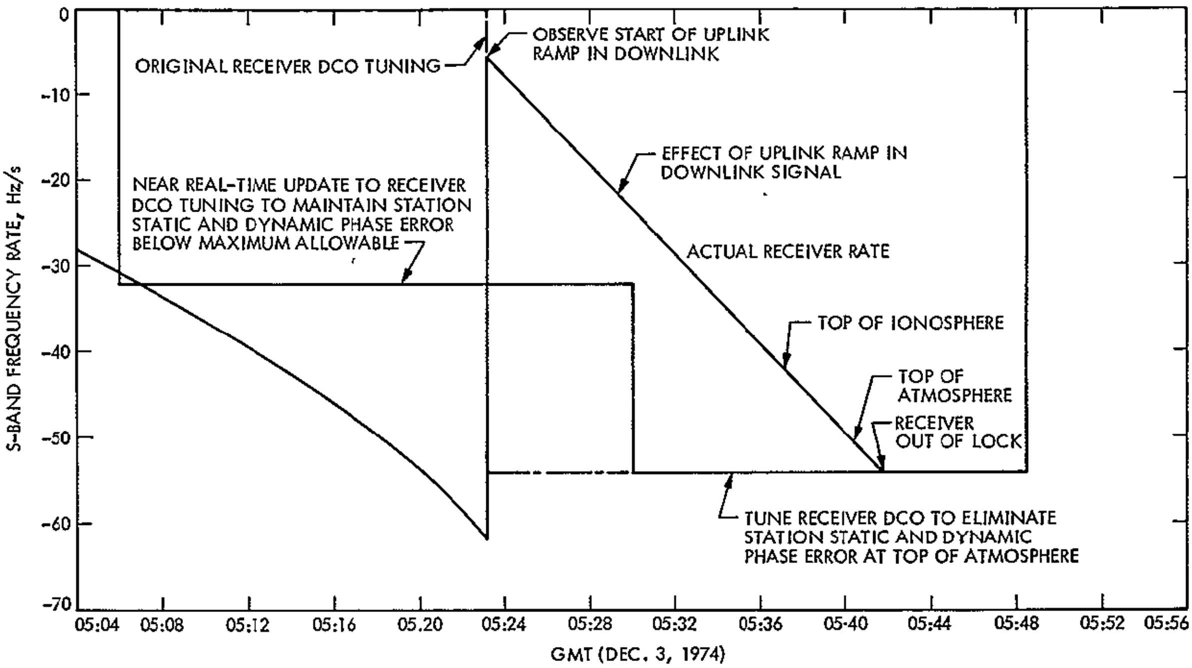


Fig. 22. DSS 14 receiver rate at enter Jupiter occultation

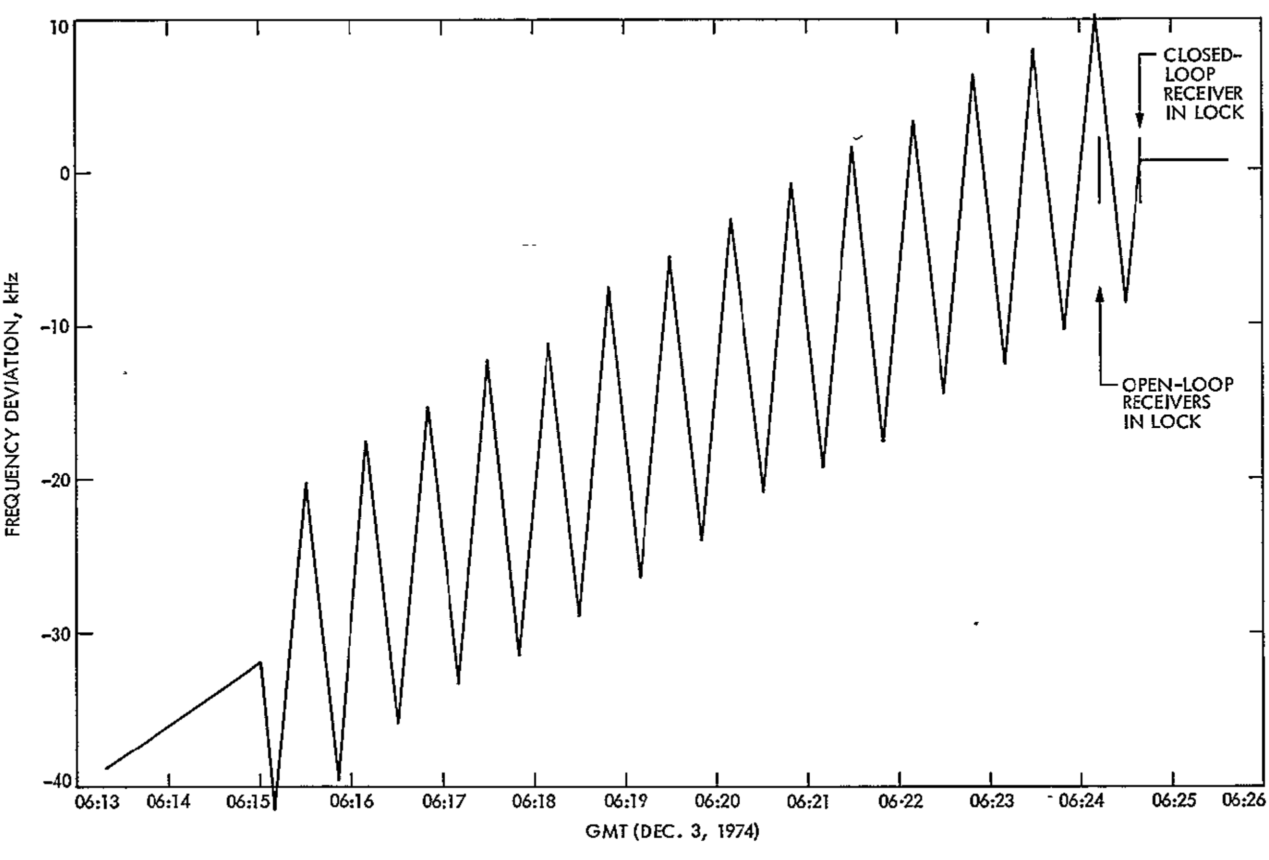


Fig. 23. DSS 14 actual minus predicted one-way doppler at exit Jupiter occultation

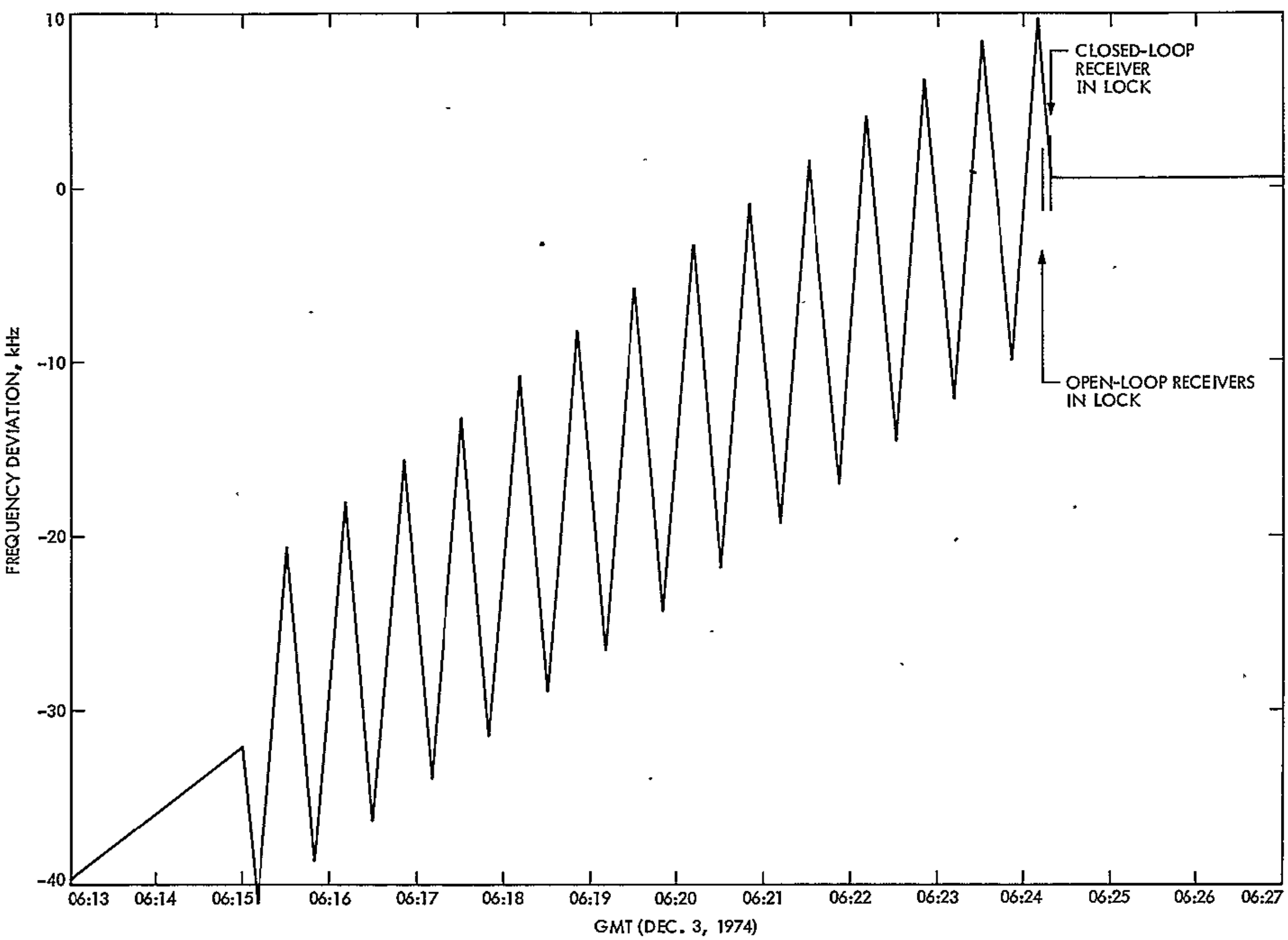


Fig. 24. DSS 43 actual minus predicted one-way doppler at exit Jupiter occultation

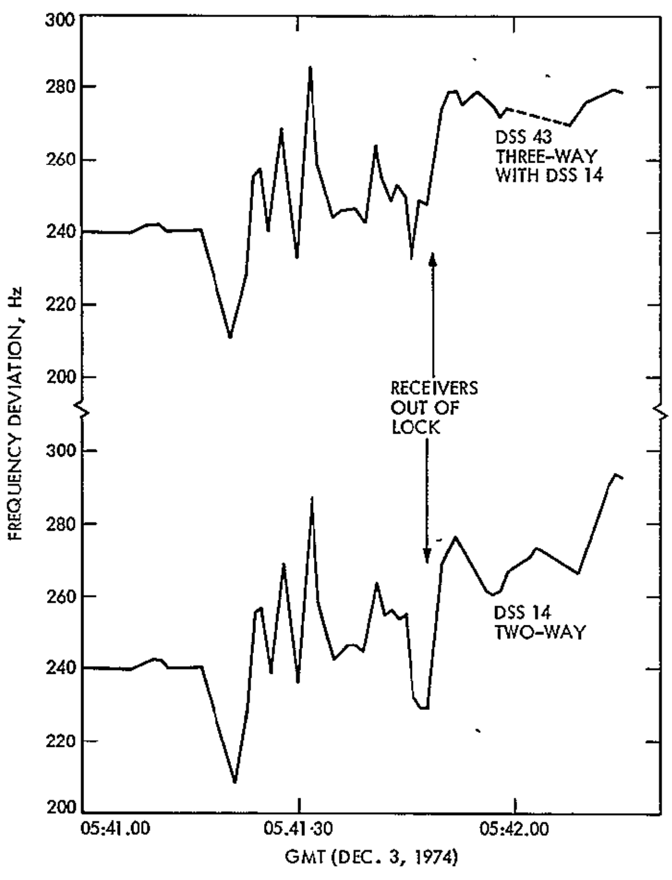


Fig. 25. DSSs 14 and 43 actual doppler minus predicted doppler at enter Jupiter occultation

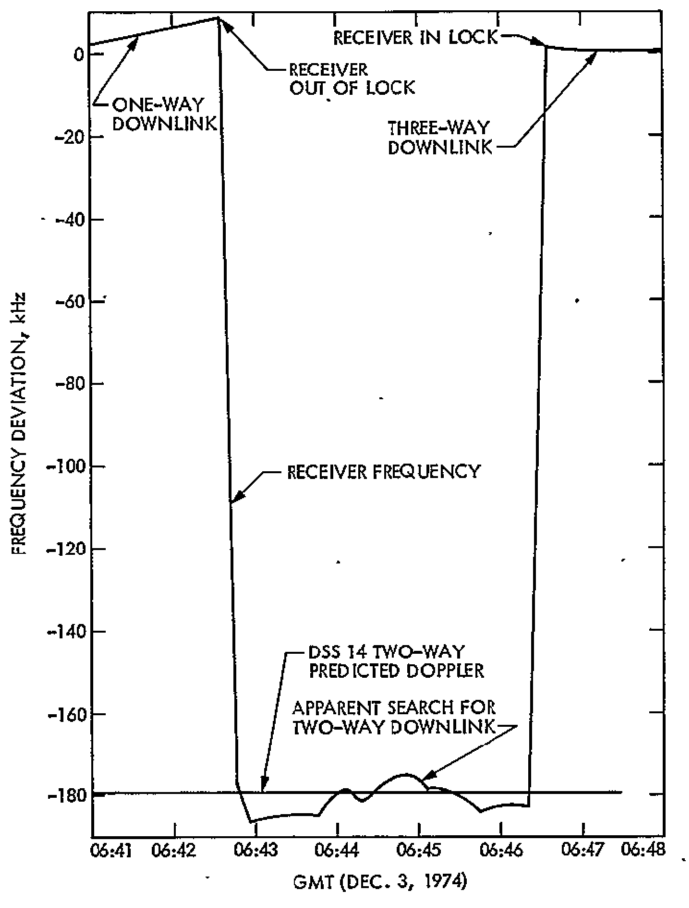


Fig. 26. DSS 14 actual minus predicted three-way doppler with DSS 43 at acquisition of coherent downlink

V. ANALYSIS OF DSN PIONEER 10 AND 11 SUPPORT

A. GENERAL

At the close of this report period, the DSN continued to fulfill all requirements in support of the Pioneer 10 and 11 missions. Both Pioneer 10 and 11 spacecraft were continuing to function normally and to return new information on the interplanetary medium beyond the orbit of Mars.

B. NETWORK CHANGES DURING REPORT PERIOD

The network configuration of Deep Space Stations and their capabilities are given in Table 2. (Note Subsection IV-A-2.)

On June 19, 1973, DSS 44 demonstrated the capability to support both the Skylab and Pioneer operations. Thus the certification to meet all requirements of the DSN/STDN interface was completed ahead of schedule. However, in August 1974, modification of DSS 44 to standard DSN configuration began. This called for changes in the antenna as well as the addition of Antenna Pointing (APS), Digital Instrumentation (DIS), and Tracking and Data Handling (TDH) subsystems. The station control area also was relocated from Tidbinbilla to Honeysuckle Creek. The station was not operational again until January 13, 1975 after the crucial Pioneer 11 encounter period. DSS 63 had a down period of August-October 1974 for addition of an X-band cone and extensive repairs on the elevation gear box.

There were two periods of downtime, with resulting improved capability, for DSS 14 (Goldstone). In June 1973 a manually programmed digitally controlled oscillator (DCO) was installed, and ramping tests were conducted with Pioneer 10 spacecraft, which was to encounter Jupiter in December 1973. The ranging data were obtained from the spacecraft by using the DCO to ramp the transmitter frequency. The results were that range to the spacecraft could be established to an accuracy of 10 km by the ramp ranging techniques. Then, on April 24, 1974, the high-power (100-kW) transmitter at DSS 14 was shut down for approximately four weeks for major rework and modification. This modification included installation of a new klystron to raise the maximum power to 400 kW. Bearing regrout and numerous Viking modifications also caused a shutdown of the station in September 1974. However, in October 1974, DSS 14 took part in Pioneer 11 encounter training tests and an operations readiness test along with DSSs 43 and 63.

A one-second adjustment was incorporated in the station time throughout the Network during the change from December 31, 1974 to January 1, 1975. This adjustment was incorporated to correct for the gradual drift of Ephemeris Time (ET) compared to Universal Time (UT), in particular universal time codes. The change was of such a nature as to cause GMT to be set to a value one second earlier than it otherwise would have been.

C. SUPPORT BETWEEN ENCOUNTERS

1. Solar Conjunctions

During February 1974, both spacecraft went through a solar conjunction.

Two important factors affect Pioneers 10 and 11 during a solar conjunction. The first is the desire to maintain the high-gain antenna pointed as near to the Earth direction as possible in order to maintain the uplink and downlink margin to the spacecraft. When the Sun, during solar conjunction, gets within a few degrees of the spacecraft-Earth line, the solar sensor on the spacecraft is unable to operate. The solar sensor is utilized to produce a roll pulse which serves as the pointing reference for all of the on-board instruments. It is, therefore, necessary to point the spacecraft slightly off the Earth-spacecraft line in order to avoid loss of roll reference. This requires a successive precessing of the spacecraft during a solar conjunction to step around the Sun position and avoid loss of roll reference while still maintaining good communications with Earth.

The second factor during solar conjunction is the fact that the spacecraft design on both Pioneers 10 and 11 has incorporated protection against receiver failure by automatically causing the spacecraft to switch to the redundant receiver in the event that an uplink has not been detected within 36 h. This requirement necessitated the establishment of a daily uplink to the Pioneer spacecraft right through the solar conjunction period in order to prevent the switching of the Radio Subsystem. This automatic switching can be inhibited by ground command; so it was decided, since Pioneer 10 had achieved Jupiter encounter, that the risk of inhibiting this function on Pioneer 10 would be acceptable for this solar conjunction. It was held, however, that the risk would be too high for Pioneer 11, so a daily uplink would have to be established. This daily uplink required, during

the height of solar conjunction, a 64-m antenna in order to break through the solar corona into the spacecraft receiver. On about February 2, 1974, Pioneer 10, with the automatic receiver switching inhibited, was maneuvered off to a position that would cause Earth to come back into the beam of the high-gain antenna after solar conjunction. This decision by the Pioneer Project Office greatly relieved the excessive demand on 64-m coverage in this time period. The 64-m coverage required by Pioneer 11 was achieved principally by using partial passes shared with MVM'73.

During the solar conjunction on February 19, the Sun-Earth-probe (SEP) angle was virtually 0 deg for Pioneer 10 and 1.4 deg for Pioneer 11. Pioneer 10 also had undergone solar conjunction a year previous (January 16, 1973), at which time the SEP angle decreased to 1.2 deg.

The doppler pseudoresidual standard deviation (doppler noise) increased with decreasing SEP angle, reaching an absolute maximum at the time of conjunction of both spacecraft. From a graphical analysis of the data, two other items of interest were detected (Fig. 27).

The first item of interest was the apparent asymmetry of the curve. The noise appears to rise more gradually prior to conjunction and then falls rapidly afterwards. The other item is the appearance of large local maxima on both sides of conjunction. These local maxima are very large (0.020 Hz higher than the surrounding data) and appear at a large angular displacement from the Sun (the first ones occur at an SEP angle of approximately 15 deg). Study is continuing in an attempt to explain both of these phenomena. Normally this would have been accomplished by extrapolating backward from the time of downlink mode change (from one-way to two- or three-way) by one RTLT. Uplink acquisition was considered routinely successful, however, as evidenced some minutes later by the successfully received and executed command to the spacecraft to return to coherent operations.

2. Precession Maneuvers

There were two precession maneuvers performed in May 1973. The first on May 18 was accomplished to orient the Pioneer 11 spacecraft antenna to Earth line. On May 25, the precession maneuver was performed for trim purposes. No special predicts for pre- or post-maneuver were required.

Pioneer Project performed a large midcourse maneuver on Pioneer 11 on April 19, 1974. The maneuver was accomplished in two separate parts, which caused a total shift of approximately 1000 Hz of two-way doppler (i. e., 66 m/s).

The first part took place at 1600Z SCE (spacecraft event time) and required approximately 20 min. The second part took place at 0100Z SCE and required 21 min. The overall effect resulted in an approximately 5-Hz excess shift; numerous small trims were then performed to reduce this shift to a few tenths of a hertz.

Following each burn, a new PET was delivered, and a special predicts run made to determine the degree to which the actual burn matched the desired one by observing the pseudoresiduals computed in the IBM 360/75.

Originally, the Project personnel believed they knew the direction and magnitude of the vector representing the imbalance between the thrusters. It was therefore planned to perform the maneuver in one large burn. However, during the calibration maneuver earlier in the week, a large uncertainty in the direction of this vector was discovered, and the plan was changed to two burns in order to be able to correct for any imbalance during the second burn.

3. Stability Tests

During May 1974, the Guidance and Control Systems and Research Section negotiated with the University of Arizona Imaging Experimenters to run stability tests using the Pioneer 10 spacecraft to support an ongoing JPL "Advanced Pioneer Approach Guidance Study" being performed for the NASA/Ames Advanced Space Projects Office.

The tests required the use of high bit rate imaging photopolarimeter (IPP) imaging of Jupiter for long hours at a time. The planet would be of an ideal size and intensity during the summer and fall of 1974 in the Pioneer 10 photopolarimeter. The effect of the image constancy over these test periods would help to establish the stability performance of a spinning spacecraft. Dr. Bejczy, with the aid of the University of Arizona, would use the realtime telemetry data at the PMOCC for this purpose. Generally, 24 h of 64-m coverage was required to support these tests, but certain ones could be run using only two stations (16 h), and one or two possibly requiring 36-h periods.

D. PIONEER 11 ENCOUNTER EVENTS

Pioneer 11 bettered the 1973 success of Pioneer 10 with a closer approach to Jupiter and was retargeted toward the planet Saturn. Newly designated as "Pioneer Saturn" by NASA, the spacecraft used the massive gravity of Jupiter to "boomerang" on a 2.4 billion-km trajectory to Saturn. Pioneer 11 will reach that planet on September 5, 1979, and then possibly encounter the Saturn moon Titan.

Jovian periapsis was reached by the Pioneer 11 spacecraft at 05:22 (GMT) on December 3, 1974 after a 608-day journey. This closest approach, relative to the planet's equatorial cloud cover, was 43,000 km or 0.6 R_J (Jupiter radius = 71,000 km). (In comparison, Pioneer 10 took 641 days to reach Jupiter periapsis (December 3, 1973) at a range of 130,000 km.) Then, Pioneer 11 was accelerated by Jovian gravity to a record peak velocity of 172,800 km/h (nearly double the entrance speed).

Entrance day of the encounter phase of the Pioneer 11 Jupiter mission was November 3, 1974; January 3, 1975 was exit day. The bowshock wavefront of the Jovian magnetosphere was crossed at 06:00 (GMT), November 26, 1974, and the magnetosphere was reached at 05:00, November 27. The spacecraft disappeared behind Jupiter at 05:21, December 3, and reappeared 41 min later. At this time, the delay of signals to the ground system was 41 min. The end of the critical encounter phase was December 10.

Figure 28 displays all major encounter events, and shows the spacecraft outgoing velocity, which increased by almost a factor of two from Jupiter's giant gravitational field. Figure 29 depicts the sequence of events during the first four days of December. This figure is a summary of the daily activities as the spacecraft made its closest approach.

E. DSN PERFORMANCE DURING PIONEER 11 ENCOUNTER

1. General

The overall support performance for the Pioneer 11 Jupiter encounter was at the same high level of DSN reliability as was demonstated during the Pioneer 10 Jupiter encounter. This was attained despite launch of the Helios-A spacecraft only 7 days after Pioneer 11's closest approach to Jupiter.

The performance of the Ground Data System (GDS) and, in particular, the DSN portion of the GDS was such that there was no compromise in the science return during the 60 days of encounter because of a GDS or Network problem.

As with Pioneer 10, the biggest concern for the total GDS was command reliability. This is the case with the Pioneer 10 and 11 missions because of the fact that both missions involve flying an extremely complex planetary encounter sequence without the aid of an on-board programmer. A tremendous number of commands are required to operate the encounter sequence, with the majority of the command requirement due to a single instrument, the imaging photopolarimeter. Pioneer 11 required 28% fewer commands than Pioneer 10, mostly because of better performance of the IPP instrument. Problems with gain control and stepping that existed on Pioneer 10 had been corrected on the Pioneer 11 instrument prior to launch (Subsection IV-I-1).

2. Command Reliability

The overall command reliability of Pioneer 11 is compared to Pioneer 10 in Table 7. In this table, the reliability is compared using the total number of DSN aborts, where an abort is defined as a failure of a command to transmit in realtime because of a DSN-caused failure or operator error. Of the 17,286 commands transmitted during the Pioneer 10 60-day encounter period, there were 7 DSN aborts, resulting in a total command reliability of 99.96%. The figure for Pioneer 11 is comparable in that there were 12,358 commands transmitted during the 60-day encounter period of which 8 were aborted due to a DSN problem, resulting in a total command reliability of 99.94%. Of those eight failures, four were caused by the same type of failure as at DSS 63, which resulted in elapsed timed commands. This failure occurred during several DSS 63 passes in November until the problem was finally isolated to a timing problem in a particular Telemetry and Command Processor.

The total number of realtime aborts is not a complete measure of the Command System reliability and its effect on Project execution of the encounter sequence. This is because once the failure has occurred, the Project ceases trying to transmit commands until the Command System is restored. In order to get a picture of this aspect of the Command System

reliability, the total number of failures (whether they caused an abort or not), along with the mean time between failure and the mean time to recover from the failure, is listed in Table 8. This table lists the statistics for four different levels of support.

Levels of support are defined in advance as the means of committing to the Project the amount of redundancy and the amount of effort that will go into a particular track. Level 1 is the highest level of redundancy the DSN can provide where the redundant telemetry and command strings are loaded and processing simultaneously with the string which is supporting the track, and a maximum effort is made by station personnel to recover rapidly in the event of a failure in the realtime string. A 6-min recovery from a failure in redundant equipment is committed during Level 1 support. As the table shows, Level 1 support was committed for just the three passes surrounding periapsis, and there were no Command System failures during that period. Level 2 support is essentially the same equipment configuration as Level 1 support, but the recovery requirement is relaxed to less than or equal to 20 min. From Table 8 one can see that there were 144 passes where the committed Level 2 support was provided, and during those passes there were 11 failures in the Command System with a mean time to restore of only 6.45 min, well within the 20-min requirement. There were also 26 passes labeled as Level 2-F in Table 8, where the Level 2 redundant configuration could not be completely provided because of failures in the redundant equipment. Fortunately, there were no failures in the prime on-line equipment during these passes. Level 3 support does not require that the backup string be loaded and running during the pass and relaxes the recovery time requirement to less than or equal to 30 min. From the table, it is shown that there were 36 passes with Level 3 support in which only 2 failures occurred, and the mean time to recover was 22 min, which also meets the recovery requirement.

As was the case for Pioneer 10 encounter, during Pioneer 11 encounter the overall performance of the Ground Data System and, in particular, the DSN portion of the Ground Data System was such that there was no compromise in the science return during the 60 days of encounter because of a Ground Data System or DSN problem.

F. PERFORMANCE BY DSN SYSTEM (PIONEER 11)

A report by system of the support of the Pioneer 11 Mission, with emphasis on the encounter period, follows here. A pass chronology is detailed in the Appendix.

1. DSN Tracking System

a. Overview. Pioneer 11 tracking coverage support by station from launch, April 6, 1973, through Jupiter encounter period, January 3, 1975 (Pass 1 through Pass 641) was as follows:

DSS	Number of support tracks	Station hours expended
11	382	4481
12	132	924
14	111	1342.5
42	201	1738.5
43	100	1733.5
44	347	3189
51	374	4709
61	109	1178
62	30	454.5
63	95	855

Passes 1 through 25 were also reported in Technical Memorandum 33-584, Volume II. Station totals during that period (April) were: DSS 11 - 9 tracks, 38.5 h; DSS 12 - 16 tracks, 172.5 h; DSS 14 - 2 tracks, 18 h; DSS 42 - 25 tracks, 269 h; and DSS 51 - 25 tracks, 350 h.

A total of 171 tracks with 2169.5 station hours was expended during the Pioneer 11 spacecraft Jupiter encounter period (November 3, 1974 - January 3, 1975). Tracks and station hours by station were as follows:

DSS:	12	14	42	43	63
Tracks:	1	46	5	57	62
Hours:	7	668.5	39.5	664.5	790

The doppler residuals computed throughout the report period by the pseudoresidual program indicate that the probe ephemeris tapes (PET) supplied by Pioneer Navigation were relatively accurate. Average Pioneer 11 doppler noise during November and December 1974 was 0.002 Hz. This had been the constant monthly average since June 1974. Noise levels were nominal during most of the report period. However, in late 1973 and early 1974, the plots show intermittent high noise levels were experienced. The increases were believed to be the result of the decreasing Sun-Earth-spacecraft angle. Comparison of Pioneer 10 and 11 doppler noise plots indicated the data from each spacecraft, regardless of which station was tracking, were high during the same period.

Figures 30 and 31 are plots of doppler noise values for Pioneer 11 for 1973 and 1974. Figures 32, 33, 34, and 35 are plots of the measured frequency values for Pioneer 11 on-board noncoherent oscillator (TFREQ) and best-lock frequencies. The data indicate actual observed frequencies.

2. DSN Telemetry System

With installation of an ultracone at DSS 11 on October 31, 1974, which changed the average system noise temperature (SNT) from approximately 33 to 25.7 K, a study of the expected improvement in downlink signal-to-noise ratio (SNR) was made in November. Study results showed that, while the theoretical improvement was approximately +1.1 dB (10 log 33 deg - 10 log 25.7 deg), the actual improvement was +0.5 dB. The observed efficiency then was 45%.

For mission-dependent link analysis, downlink signal level and SNR residuals (in dB) for Pioneer 11 spacecraft and the tracking subnets (26-m or 64-m) are computed in terms of the mean and standard deviation (Table 9). An estimated 3-sigma limit was used to determine which points should be considered anomalous. The number of observations within the estimated 3-sigma limit, the mean, and the standard deviation for the spacecraft subnet pairing are given.

Downlink summary of residual information from launch through July is shown in Table 10. SNR summary of residual information from launch through July is shown in Table 11.

For station-dependent link analysis, downlink signal level and SNR residuals (in dB) for each station/spacecraft pair are computed and also shown in terms of the mean and standard deviation in Tables 12 and 13. An estimated 3-sigma limit was established, and points beyond were not included in the number of observations. Also computed was the SNT mean and standard deviation for each station/spacecraft pair. The SNR residual is computed on the basis of the SNT for the day; thus, to help underscore the improvement obtained, the SNT mean is computed. Where there were too few tracks to obtain a good data base, blanks have been inserted in the appropriate columns.

The Earth-look angle for Pioneer 11 spacecraft was kept within a tolerance of 0.5 dB during December, and the result was that its signal level and SNR residuals were less noisy than for the other spacecraft.

Significant anomalous points for residuals were reported by stations for the encounter period as presented below.

For DSS 14, there were two such points in November. On November 16, the SNR residual was -1.2 dB because a CONSCAN maneuver and bit rate changes made a pass average inaccurate. Then on November 21, the downlink signal level residual was +1.4 dB because the station used the wrong automatic gain control (AGC) curve in the Digital Instrumentation Subsystem (DIS). During December, downlink residuals continued to have a mean residual of near 0.0 dB, while the SNR residuals continued to have a mean of about +0.3 dB. There was difficulty in reaching conclusions on the data since Pioneer 11 was the only spacecraft tracked regularly for several months.

DSS 43 appeared to have no consistent station-dependent bias on the basis of the data reviewed for the encounter months. For Pioneer 11 tracks, DSS 43 had had a negative signal level residual (-0.1 dB) and a positive SNR residual level (+0.3 dB). This may have been the result of the spacecraft's Earth-look angle being kept within a tight tolerance (±0.5 deg) during the encounter period. There was an anomalous point for Pioneer 11 residuals when, on December 6, the AGC residual was 1.5 dB because of an instability

in maser gain. Previously, on October 30, there had been an anomalous point at the station when the downlink signal level residual was 1.8 dB. DSS 43 was one-way and the high residual was the result of a known problem in this mode.

At DSS 63, tracking Pioneer 11 only during the last months of 1974, the signal-level residual was negative (about -0.5 dB), while the SNR residual had been approximately 0.0 dB. During November, the SNR residual was -1.2 dB; the pretrack SNT was 28 K, and the post-track SNT was 22 K. Calculation of the residual was based on the pre-track SNT of 28 K, resulting in the large residual. Then, on November 13, the downlink signal level residual was -1.7 dB. The S-band polarization diversity (SPD) maser gain drifts required returning to a more stable mode. Because drifts were not fully corrected, the klystron had low output. The klystron was changed. On November 20, the downlink signal level residual was -2.2 dB, when the antenna stopped and degraded signal level.

3. DSN Command System

Cumulative command total from launch through the end of the encounter period was 39,588. There were 25 system aborts and 20 project aborts. (A project abort is a command aborted by Pioneer Project, that is, disabled while active; a system abort is one caused by a Command System failure.) Table 14 gives cumulative commands and aborts by station.

Four Deep Space Stations supported Pioneer 11 during the Jupiter encounter period (November 3, 1974 - January 3, 1975) with commands as follows: DSS 14 - 3110 commands; DSS 42 - 287 commands; DSS 43 - 3848 commands; and DSS 63 - 5334 commands. There were three system aborts, all at DSS 14, and 3 project aborts, with one each at DSS 14, DSS 43, and DSS 63.

High-speed data line outages were reported for Pioneer 11 at three stations during November 1974. DSS 14 had 4 outages totaling 42 min, DSS 43 had 3 outages totaling 31 min, and DSS 63 had 5 outages totaling 43 min. During December, HSDL outages were reported at three stations: DSS 14 had one outage of 3 min; DSS 43 had two outages totaling 5 min; and DSS 63 had one outage of 6 min.

Cumulative percentage of station downtime for the mission at the end of December was 0.581.

There were significant problem areas for Pioneer 11 on six passes in November and four during December.

a. <u>November</u>. On Pass 588 at DSS 63, command message 004-04 failed to go active, and this resulted in an elapsed timed command during an imaging photopolarimeter (IPP) sequence. A switch was made to Command Modular Assembly B (CMA-B), which was up and running as backup. Command capability was impacted for a total of 6 min.

A command message aborted on Pass 592 at DSS 14, when Project sent a command before the scheduled command modulation on time.

Command messages 010-04 and 011-07 failed to go active and resulted in elapsed timed commands on Pass 594 at DSS 63. The procedure involved at this time was to halt commanding, clear the stack, perform a Data Validation Test, and then resume commanding.

On Pass 596 at DSS 63, acquisition of signal was delayed by 55 min because of an antenna halt caused by a shorted solenoid valve in the accumulator. The valve was replaced.

There appeared to be a timing problem on Pass 601 at DSS 63, when multiple elapsed timed commands were received on TCP-B. Commanding was switched to TCP-A, while TCP-B was released for troubleshooting of the problem.

Then on Pass 606 at DSS 63, Data Decoder Assembly A (DDA-A) halted while providing committed backup support per requirements. A reload was required, causing an outage time of 49 min.

b. <u>December</u>. On Pass 608 at DSS 14, commands 97-7 and 98-1 aborted because of "F0 subca freq" limits were exceeded. TCP/CMA-A was prime. This outage caused a 17-min delay in commanding during critical Jupiter encounter support. A switch was made to TCP/CMA-B. The Alpha Command System was revalidated after a reload and made backup.

Then on Pass 609 at DSS 63, an elapsed timed command alarm was received when TCP/CMA-B failed to go active on message 28-2. It was confirmed that the command had been properly entered and enabled. This

failure, causing a 5-min delay, occurred during Jupiter encounter support, and it was necessary for Project to disable some commands in stack. However, commanding continued on CMA-B with no further incident. This type of anomaly had been a recurring problem.

On Pass 613 at DSS 14, command 44-1 aborted during IPP command sequence because "F0 subca freq" limits were exceeded. Commanding was switched from TCP/CMA-B to TCP/CMA-A for realtime resolution. There was a delay of 9 min to project commanding. The station subsequently replaced the Beta CMA frequency synthesizer.

There was a 33-min loss of command capability on Pass 636 at DSS 14, when the antenna went to brake because of failure of the master equatorial encoder. An uplink reacquisition was performed.

G. PERFORMANCE BY DSN SYSTEM (PIONEER 10)

1. DSN Tracking System

More than 10,000 station hours were expended in support of the Pioneer 10 mission during the year 1974. Hours spent and tracks supported station by station were as follows:

DSS	Number of tracks supported	Station hours
11	99	324
12	176	1963
14	42	453
42	120	1169
43	121	1292
44	22	169
51	34	432
61	60	1281
62	158	2066
63	90	979

Probe ephemeris tapes provided by the Pioneer Navigation Team were reasonably accurate as indicated by the doppler residuals computed by the

pseudoresidual program. Figure 36 is a plot of doppler noise values for Pioneer 10 for 1974. The average Pioneer 10 doppler noise during December was 0.002 Hz. The noise was expected to continue at this level during January 1975.

Figures 37 and 38 are plots of the measured frequency values for Pioneer 10 on-board noncoherent oscillator frequency (TFREQ) and channel 6 best-lock frequency for the year. Frequency predictions based on these plots are used in the generation of tracking predicts and for spacecraft acquisitions. They have proven to be both reasonably accurate and reliable.

2. DSN Telemetry System

As the year closed, Pioneer 10 had mean residuals with a negative bias for the second month. However, a trend, especially for signal level, was difficult to assume since the stations had some drift because they did not perform a full automatic gain control (AGC) calibration in the Digital Instrumentation Subsystem (DIS) every day.

DSS 11 continued to have negative residuals for both signal-to-noise ratio (SNR) and signal level on Pioneer 10 tracks during December. This tendency for SNR negative bias was due to the S-band polarized ultracone (SPU). The residuals are calculated with respect to system noise temperature (SNT), and the full theoretical improvement was not observed. However, since Pioneer 10 was the only spacecraft tracked, it was considered too early to judge that DSS 11 had a strong negative bias. There were two anomalous points for Pioneer 10 residuals at the station during December. On December 9, the AGC residual was -1.6 dB, and, on December 12, the AGC residual was -1.9 dB because of a bad AGC curve.

Tables 15 and 16 are summaries of downlink and SNR residual data information for Pioneer 10 for 1974.

3. DSN Command System

The command total for Pioneer 10 for 1974 was 22,746 commands (see Table 17 for count per station). There were three system aborts and three project aborts. More than 70,000 commands have been sent since launch. Table 18 presents the cumulative command and abort totals by station since launch.

Table 7. Command reliability during Pioneer 10 and 11 Jupiter encounter

Mission	Total commands transmitted during 60-day encounter	Total number of DSN aborts[a]	Total command reliability,[b] %
Pioneer 10	17,286	7	99.96
Pioneer 11	12,358	8	99.94

[a]Defined as failure of a command to transmit in real time due to a DSN-caused failure or error.

[b](Total commands – number of aborts)/total commands.

Table 8. Command system reliability during Pioneer 11 Jupiter encounter

Support level	Number of passes	Number of failures	Mean time between failures, h	Mean time to recover, min	Reliability,[a] %
1	3	0	—	—	100.00
2	144	11	93.8	6.45	99.89
2-F[b]	26	0	—	—	100.00
3	36	2	153.9	22	99.76

[a](Track time – total time failed)/track time.

[b]Failure to provide committed Level 2 configuration.

Table 9. Pioneer 11 spacecraft residuals for September-December 1974

Month	Number of observations	Mean, dB	Standard deviation, dB
Downlink			
September	85	-0.1	0.8
October	75	+0.04	0.59
November			
26-meter	8	0.0	0.4
64-meter	84	+0.1	0.5
December			
26-meter	---	---	---
64-meter	87	+0.3	0.6
SNR			
September	85	+0.4	0.6
October	81	+0.45	0.53
November			
26-meter	8	+0.2	0.4
64-meter	86	+0.2	0.3
December			
26-meter	---	---	---
64-meter	88	+0.2	0.4

Table 11 summarizes residual information from launch through July 1974. There was no summary prepared for August.

Table 10. Pioneer 11 downlink summary of residual information from launch through July 1974

Month	Number of observations	Arithmetic mean, dB	Variance, dB	Standard deviation, dB	% <1.0 dB of predicted values	% <0.3 dB of predicted values	Most often observed value, dB
1973							
Apr	72	0.9	0.7	0.8	72	22	0.8-0.9 and 0.9 to 1.0 equally
May	103	0.6	0.3	0.6		83	0.1-0.4 and 0.9 to 1.0 equally
June	89	0.5	0.2	0.4	83	33	0.1-0.2
July	98	0.5	0.2	0.5	82	34	0.1-0.2
Aug	86	0.6	0.1	0.4	83	26	0.6-0.7
Sept	90	0.7	0.2	0.5	77	21	0.5-0.6
Oct	93	0.6	0.2	0.4	81	32	0.1-0.2
Nov	89	0.7	0.4	0.6	74	27	0.3-0.4
Dec	91	0.6	0.2	0.5	79	27	0.3-0.4
1974							
Jan	90	0.6	0.4	0.6	79	24	0.3-0.4
Feb	50	0.6	0.3	0.5	82	24	0.5-0.6
Mar	60	0.6	0.2	0.5	83	25	0.3-0.4
Apr	86	0.6	0.3	0.5	81	33	0.3-0.4
May	92	0.7	0.3	0.5	75	22	0.3-0.4
June	90	0.4	0.1	0.3	90	23	0.4-0.5
July	84	0.6	0.2	0.4	99	17	0.5-0.6
Aug	---	---	---	---	---	---	---

Pioneer 11 switched to high-gain antenna system May 18, 1973 (DOY 138). Data were degraded and lost February 15, 1974 (DOY 46) to February 24, 1974 (DOY 55) because of superior conjunction.

Table 11. Pioneer 11 signal-to-noise ratio summary of residual information from launch through July 1974

Month	Number of observations	Arithmetic mean, dB	Variance, dB	Standard deviation, dB	% <1.0 dB of predicted values	% <0.3 dB of predicted values	Most often observed value, dB
1973							
Apr	72	0.6	0.3	0.6	75	29	0.3-0.4
May	103	0.7	0.3	0.6	74	20	0.3-0.4
June	89	0.6	0.2	0.5	84	28	0.5-0.6
July	98	0.5	0.2	0.4	80	28	0.6-0.7
Aug	86	0.5	0.1	0.4	90	37	0.1-0.2
Sept	90	0.5	0.1	0.3	90	24	0.3-0.4
Oct	93	0.7	0.4	0.6	78	25	0.5-0.6
Nov	89	0.5	0.2	0.4	82	28	0.3-0.4
Dec	91	0.5	0.1	0.4	82	27	0.3-0.4
1974							
Jan	90	0.6	0.2	0.4	81	23	0.3-0.4
Feb	50	1.0	0.6	0.8	56	18	0.3-0.4
Mar	60	0.6	0.3	0.5	78	32	0.2-0.3
Apr	86	0.6	0.2	0.5	85	35	0.1-0.2
May	92	0.6	0.2	0.4	76	25	0.3-0.4
June	90	0.4	0.1	0.3	90	23	0.4-0.5
July	80	0.4	0.1	0.3	91	38	0.1-0.2
Aug	---	---	---	---	---	---	---

Table 12. Pioneer 11 station/spacecraft pair residuals for October 1974

Residuals	Deep Space Station								
	11	12	14	42	43	44	61	62	63
DOWNLINK									
Number of observations	9	9	8	14	11	---	19	6	---
Mean, dB	-0.43	-0.10	+0.18	-0.06	+0.36	---	-0.12	+0.20	---
Standard deviation, dB	0.80	0.52	0.62	0.48	0.81	---	0.44	0.49	---
SNR									
Number of observations	9	12	8	14	11	---	19	7	---
Mean, dB	+0.13	+0.79	+0.64	+0.36	+0.43	---	+0.42	+0.44	---
Standard deviation, dB	0.49	0.26	0.79	0.67	0.45	---	0.28	0.53	---

Table 13. Pioneer 11 station/spacecraft pair residuals for November and December 1974

Residuals	November							December		
	Deep Space Station									
	11	12	14	42	43	62	63	14	43	63
DOWNLINK										
Number of observations	25	5	27	20	30	27	27	31	26	31
Mean, dB	-0.4	-0.2	+0.1	-0.1	-0.1	+0.3	+0.3	0.0	-0.2	-0.8
Standard deviation, dB	0.4	0.3	0.5	0.4	0.5	0.4	0.4	0.5	0.6	0.3
SNR										
Number of observations	24	5	27	18	31	27	28	30	27	31
Mean, dB	-0.7	+0.3	+0.3	-0.2	+0.3	-0.1	+0.1	+0.3	+0.2	0.0
Standard deviation, dB	0.2	0.5	0.3	0.5	0.2	0.4	0.3	0.4	0.5	0.4
SNT										
Number of observations	26	5	26	20	30	27	29	27	20 7	31
Mean, dB	25.7	29.7	21.4	31.0	21.9	31.0	22.7	20.9	22.4 26.4	21.2
Standard deviation, dB	0.4	0.2	0.6	1.6	0.7	6.5	1.9	0.5	0.9 0.9	0.4

Table 14. Cumulative command and abort totals for Pioneer 11 from launch to end of Jupiter encounter period (January 3, 1975)

DSS	11	12	14	42	43	44	61	62	63
Commands	6783	1343	4589	3389	5317	2394	1416	374	6673
System aborts	5	0	5	0	0	12	0	1	0
Project aborts	2	3	1	3	1	3	0	1	1

DSS 51 was not used in support of Pioneer 11 after June 1974. DSS 51 had transmitted 7310 commands with 2 system aborts and 5 project aborts.

Table 15. Downlink summary of residual information for Pioneer 10, January through December 1974

Month	Number of observations	Arithmetic mean, dB	Variance, dB	Standard deviation, dB	%<1.0 dB of predicted values	%<0.3 dB of predicted values	Most often observed value, dB
Jan	71	0.8	0.2	0.5	65	11	0.5-0.6
Feb	9	0.8	0.2	0.5	55	11	0.7-0.8
Mar	56	0.6	0.3	0.5	---	77	0.3-0.4
Apr	86	0.8	0.4	0.6	69	21	0.6-0.7
May	91	0.5	0.2	0.4	84	27	0.3-0.4
June	91	0.6	0.2	0.4	72	26	0.3-0.4
July	81	0.8	0.4	0.6	69	21	0.5-0.6
Aug	79	0.6	0.3	0.5	77	24	0.3-0.4
Sept	68	0.3	---	0.6	---	---	---
Oct	80	0.18	---	0.58	---	---	---
Nov	79	-0.1	---	0.5	---	---	---
Dec	56	-0.2	---	0.7	---	---	---

Table 16. Signal-to-noise ratio summary of residual information for Pioneer 10, January through December 1974

Month	Number of observations	Arithmetic mean, dB	Variance, dB	Standard deviation, dB	% < 1.0 dB of predicted values	% < 0.3 dB of predicted values	Most often observed value, dB
Jan	71	0.5	0.1	0.4	80	25	0.3-0.4
Feb	9	1.0	0.6	0.8	44	11	0.5-0.6
Mar	56	0.5	0.2	0.4	80	29	0.3-0.4
Apr	86	0.7	0.3	0.5	65	27	0.1-0.2
May	91	0.7	0.3	0.5	72	24	0.3-0.4
June	89	0.6	0.2	0.5	72	26	0.4-0.5
July	84	0.8	0.3	0.5	75	25	0.3-0.4
Aug	79	0.5	0.2	0.4	90	30	0.8-0.9
Sept	68	0.2	---	0.5	---	---	---
Oct	81	0.14	---	0.52	---	---	---
Nov	76	-0.3	---	0.5	---	---	---
Dec	59	-0.3	---	0.6	---	---	---

Table 17. Pioneer 10 command activity for 1974

DSS	11	12	14	42	43	44	61	62	63
Commands	1321	3966	1476	1783	4165	212	925	3954	4557
System aborts	1	1	1	0	0	0	0	0	0
Project aborts	0	0	0	0	0	0	1	0	1

DSS 51 totals for 1974 before being decommissioned were: tracks — 287, system aborts — 1, with no Project aborts.

Table 18. Cumulative command totals for Pioneer 10 at end of 1974

DSS	11	12	14	42	43	44	61	62	63
Commands	3583	8667	11,435	6743	15,192	214	3976	7466	8302
System aborts	4	3	27	8	6	0	2	1	3
Project aborts	3	3	6	5	0	1	3	3	4

DSS 41 and 51 are no longer employed. DSS 41 had transmitted 2557 commands with 7 system aborts and 4 project aborts. DSS 51 had transmitted 3608 commands with 1 system abort and 0 project aborts.

C.2

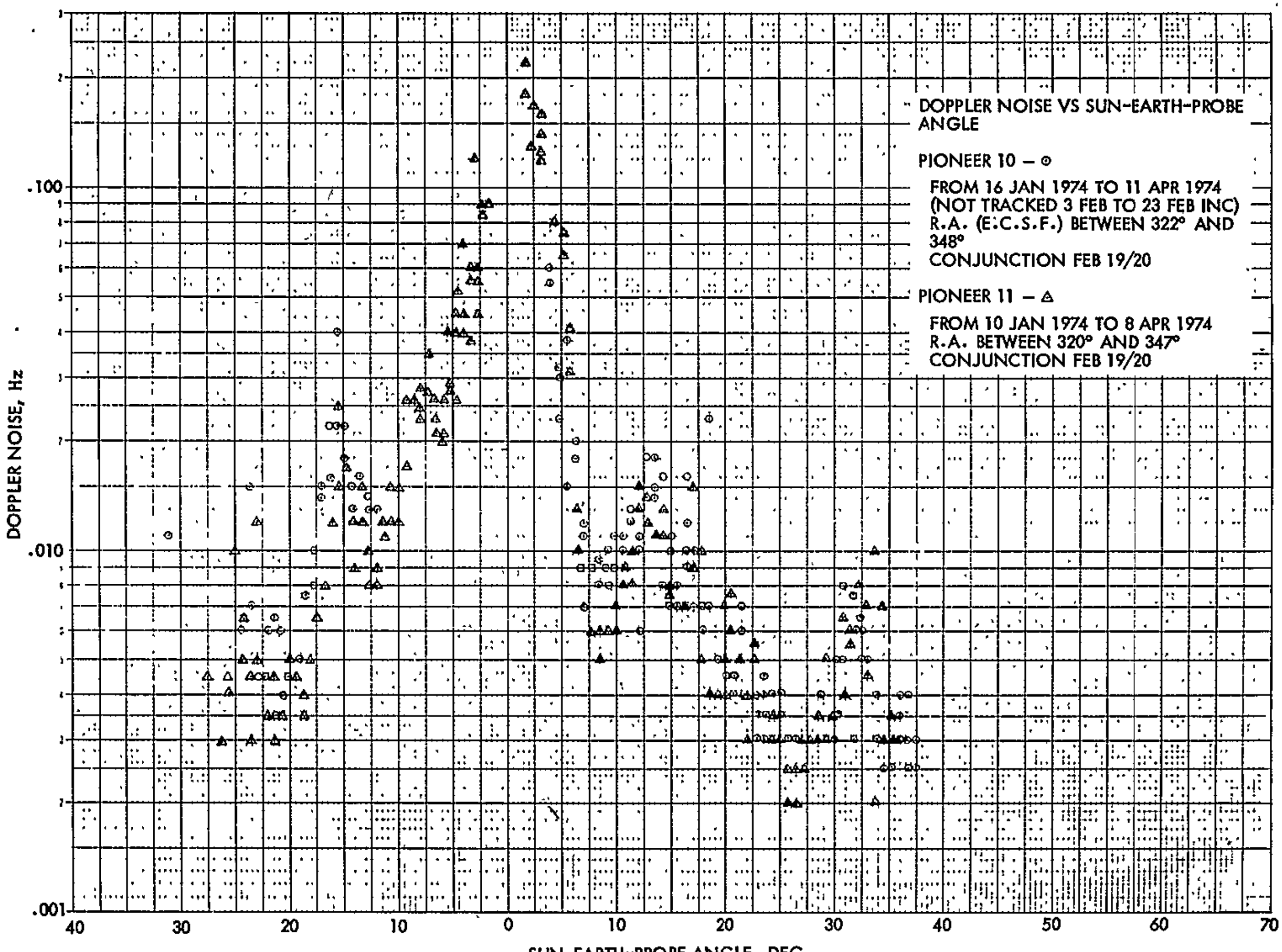


Fig. 27. Doppler noise vs Sun-Earth-probe angle

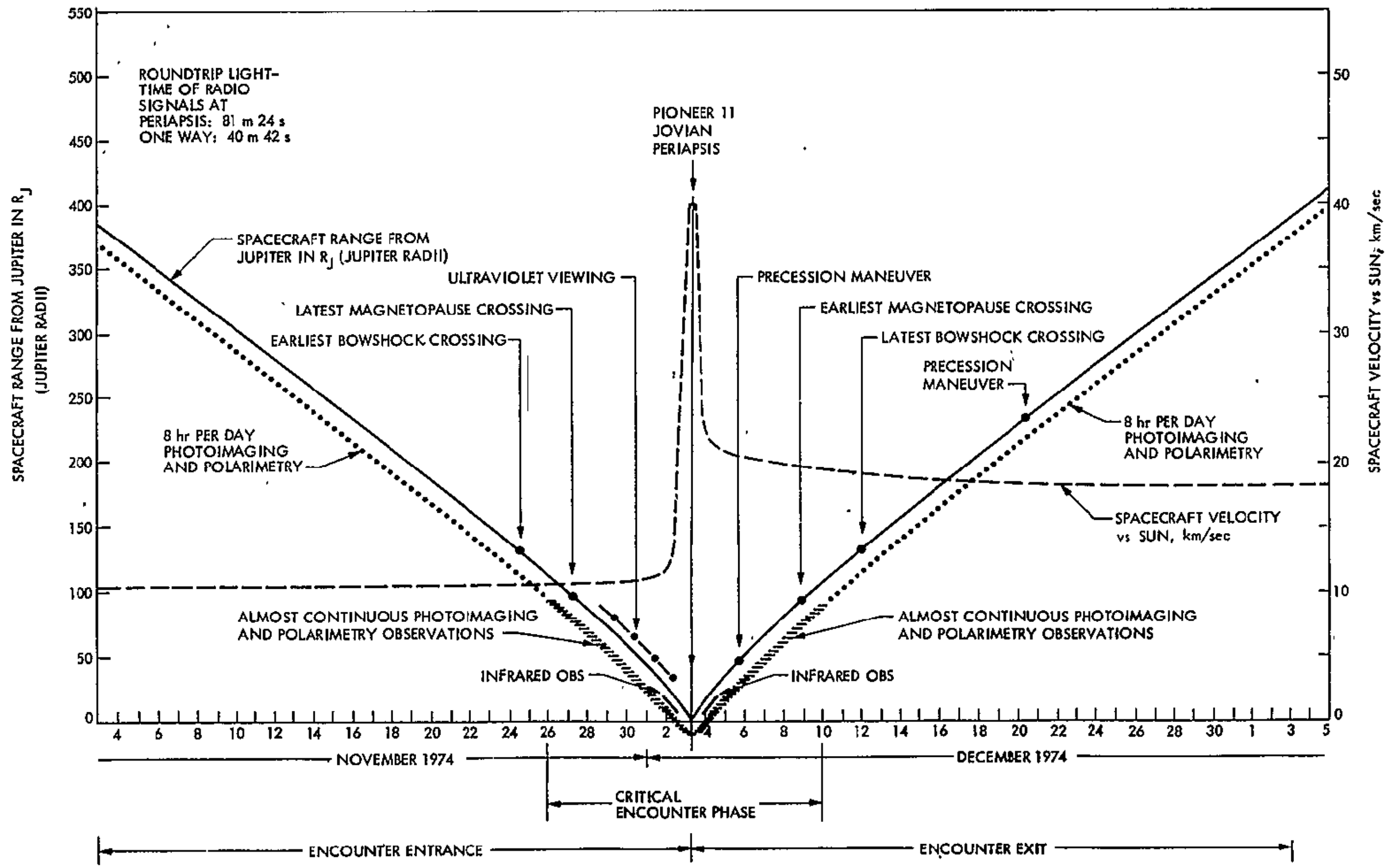
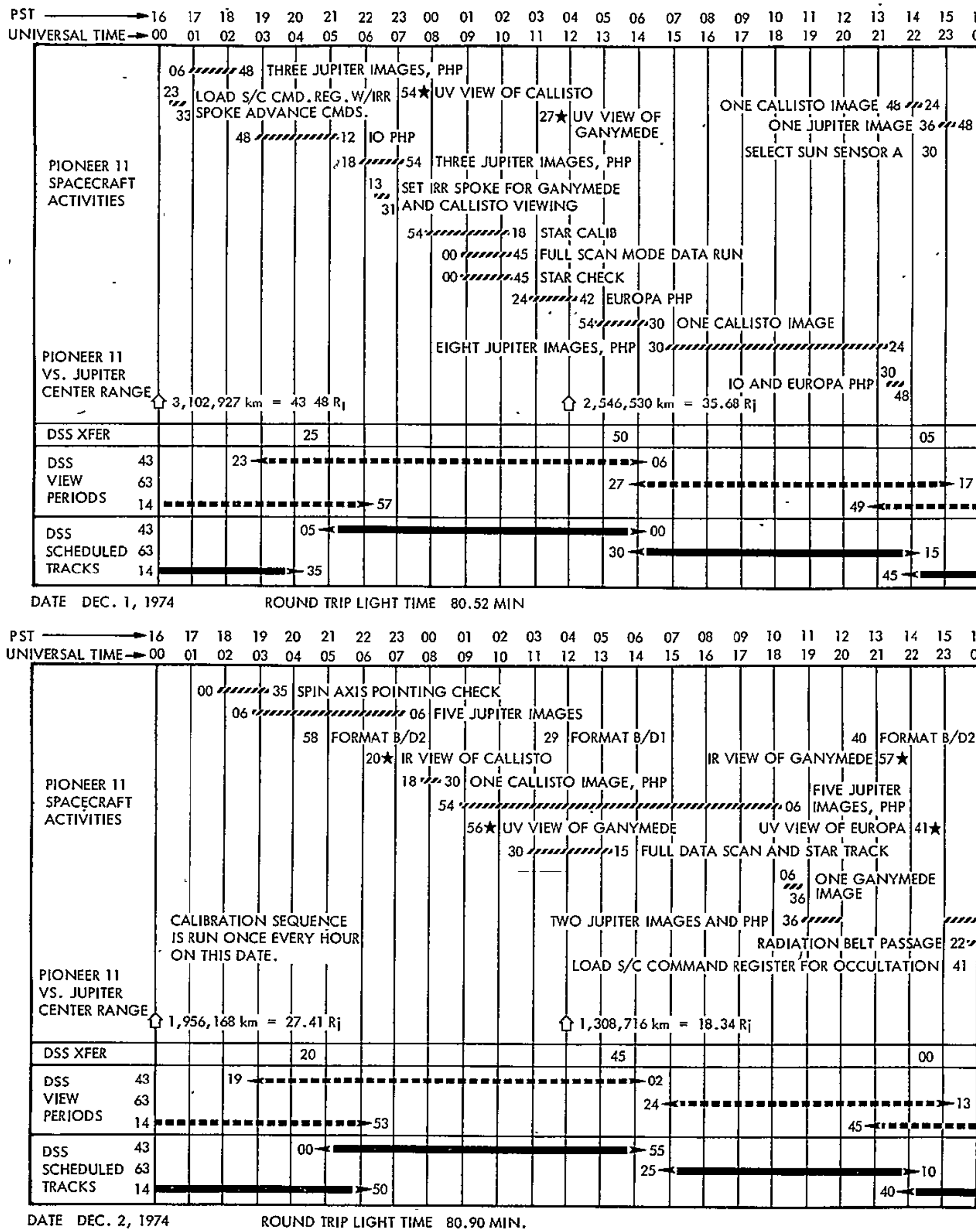


Fig. 28. Timeline events of Jupiter encounter by Pioneer 11



LEGEND: UV = ULTRAVIOLET EXPERIMENT; CMD = COMMAND; R_J = JUPITER RADIUS (71,000 km)
IRR = INFRA RED RADIOMETER; S/C = SPACECRAFT
PHP = PHOTOPOLARIMETRY OBSERVATION; DSS 43: CANBERRA; DSS 63 MADRID; DSS 14. GOLDSTONE

EVENTS SHOWN ARE IN EARTH COMMAND TRANSMISSION TIME, SPACECRAFT TELEMETRY RESPONSE WILL BE RECEIVED ONE ROUND TRIP LIGHT TIME LATER. EVENTS IDENTIFIED WITH A STAR (★) ARE IN SPACECRAFT TIME, TELEMETRY WILL BE RECEIVED A HALF ROUND TRIP LIGHT TIME LATER.

Fig. 29. Sequence of events for Pioneer 11 encounter, December 1-4

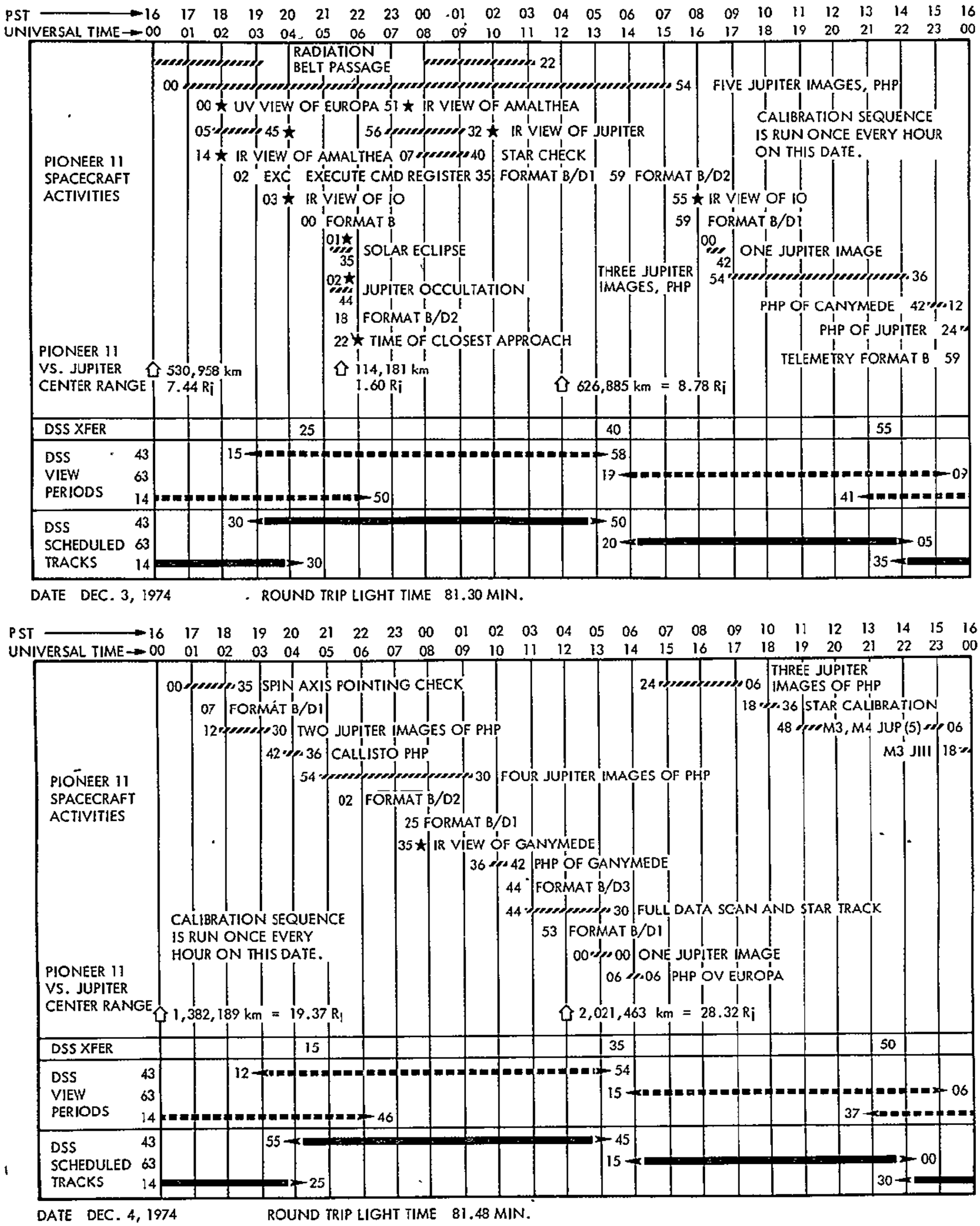

PST
UNIVERSAL TIME
RADIATION BELT PASSAGE
FIVE JUPITER IMAGES, PHP
UV VIEW OF EUROPA
IR VIEW OF AMALTHEA
IR VIEW OF JUPITER
CALIBRATION SEQUENCE IS RUN ONCE EVERY HOUR ON THIS DATE.
PIONEER 11 SPACECRAFT ACTIVITIES
IR VIEW OF AMALTHEA
STAR CHECK
EXC EXECUTE CMD REGISTER
FORMAT B/D1
FORMAT B/D2
IR VIEW OF IO
FORMAT B
FORMAT B/D1
SOLAR ECLIPSE
ONE JUPITER IMAGE
THREE JUPITER IMAGES, PHP
JUPITER OCCULTATION
PHP OF CANYMEDE
FORMAT B/D2
PHP OF JUPITER
TIME OF CLOSEST APPROACH
PIONEER 11 VS. JUPITER CENTER RANGE
530,958 km 7.44 Rj
114,181 km 1.60 Rj
626,885 km = 8.78 Rj
TELEMETRY FORMAT B
DSS XFER
DSS VIEW PERIODS
DSS SCHEDULED TRACKS
DATE DEC. 3, 1974
ROUND TRIP LIGHT TIME 81.30 MIN.
SPIN AXIS POINTING CHECK
FORMAT B/D1
TWO JUPITER IMAGES OF PHP
CALLISTO PHP
FOUR JUPITER IMAGES OF PHP
FORMAT B/D2
FORMAT B/D1
IR VIEW OF GANYMEDE
PHP OF GANYMEDE
FORMAT B/D3
FULL DATA SCAN AND STAR TRACK
FORMAT B/D1
ONE JUPITER IMAGE
PHP OV EUROPA
THREE JUPITER IMAGES OF PHP
STAR CALIBRATION
M3, M4 JUP (5)
M3 JIII
CALIBRATION SEQUENCE IS RUN ONCE EVERY HOUR ON THIS DATE.
1,382,189 km = 19.37 Rj
2,021,463 km = 28.32 Rj
DATE DEC. 4, 1974
ROUND TRIP LIGHT TIME 81.48 MIN.

Fig. 29 (contd)

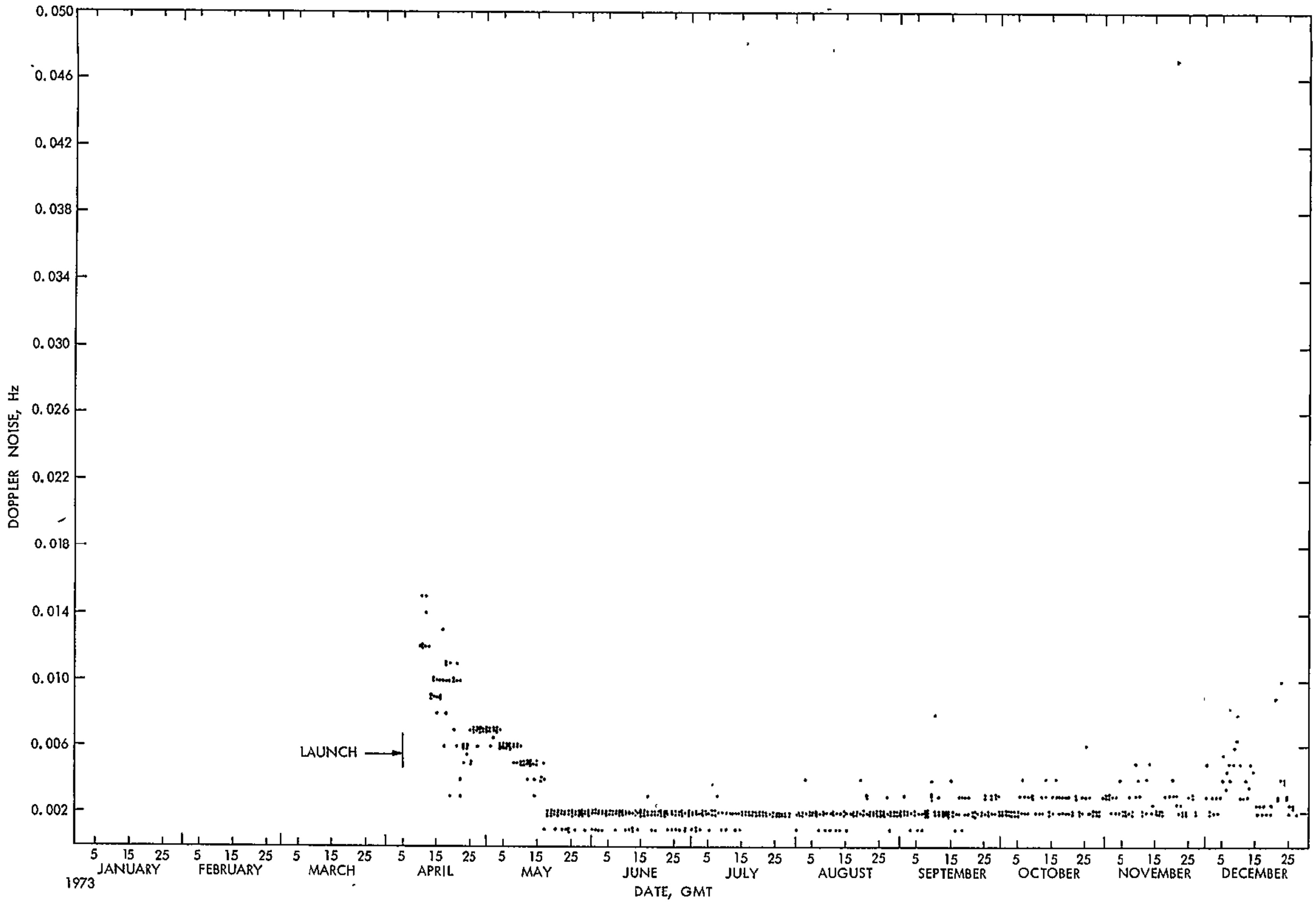


Fig. 30. Pioneer 11 doppler noise plot, 1973

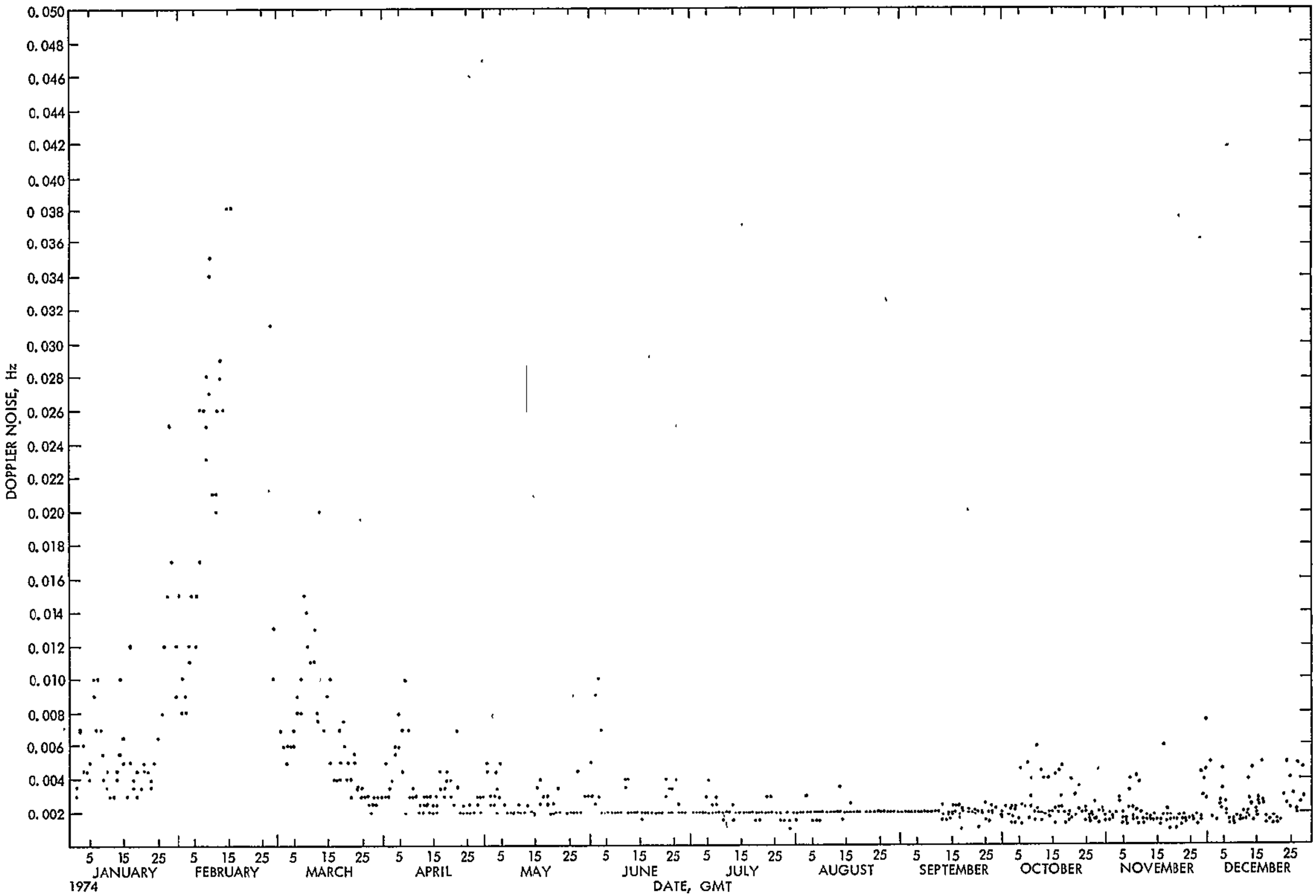


Fig. 31. Pioneer 11 doppler noise plot, 1974

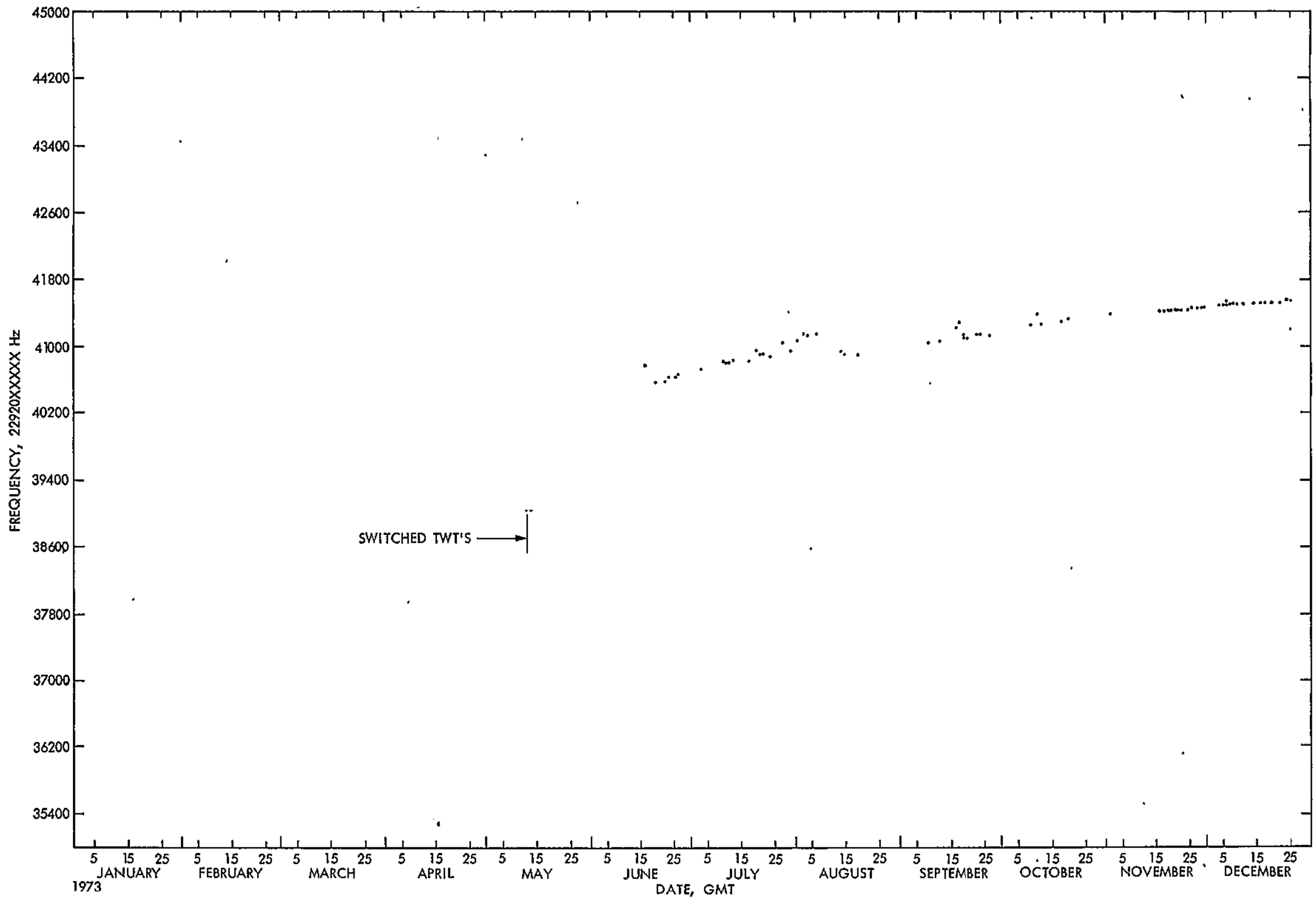


Fig. 32. Pioneer 11 noncoherent transmitter frequency, 1973

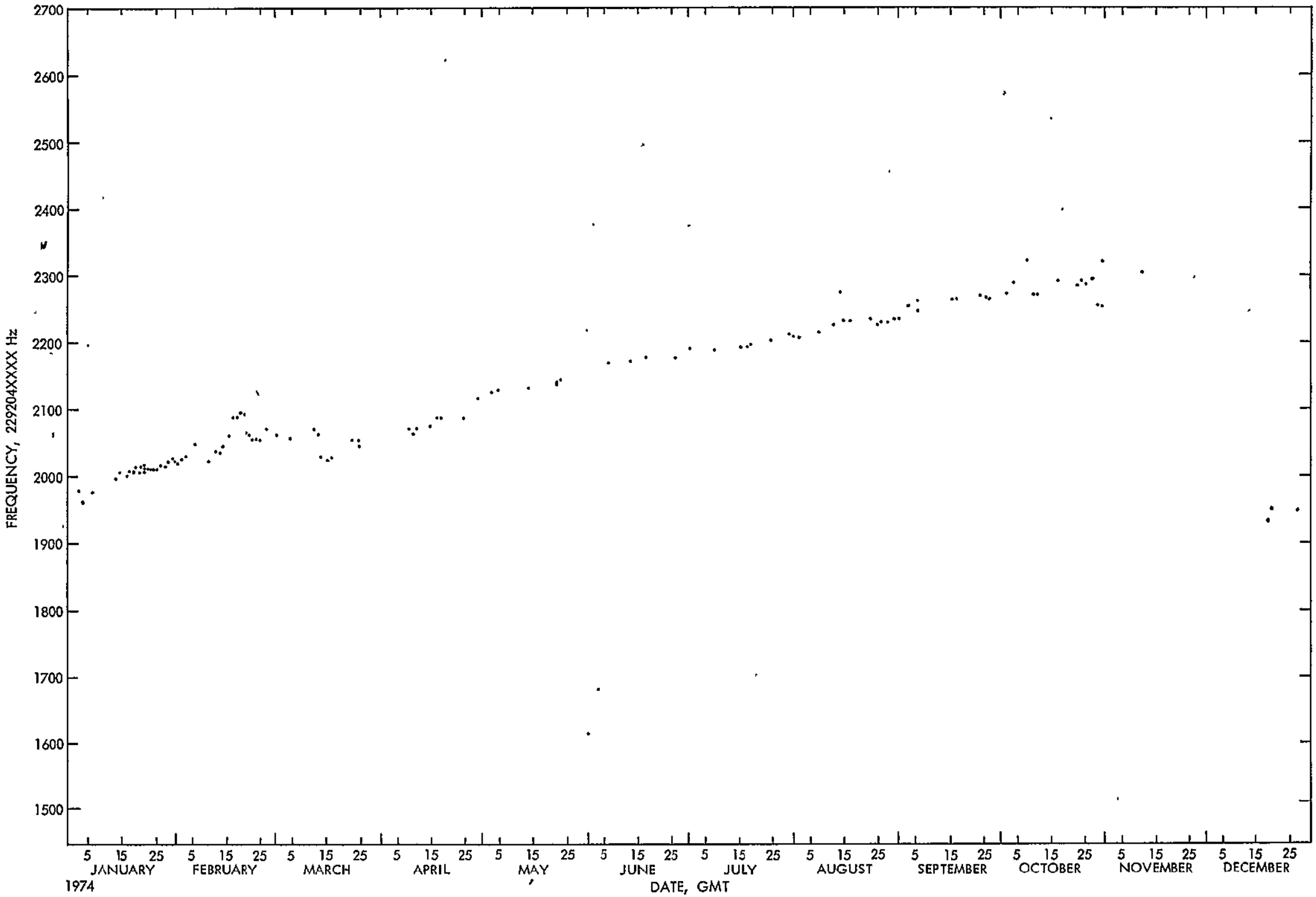


Fig. 33. Pioneer 11 noncoherent transmitter frequency, 1974

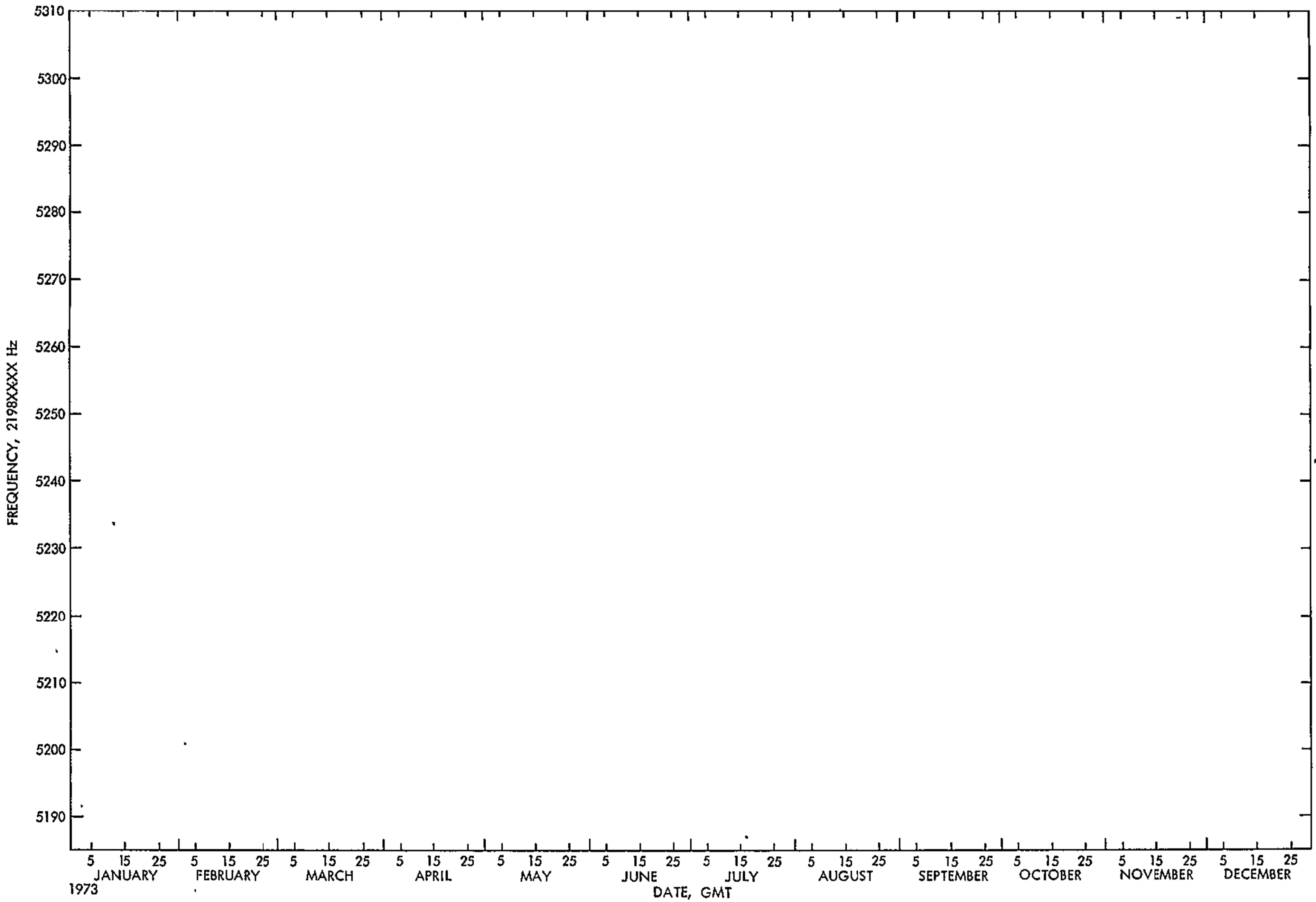


Fig. 34. Pioneer 11 channel 6 best-lock spacecraft receiver frequency, 1973

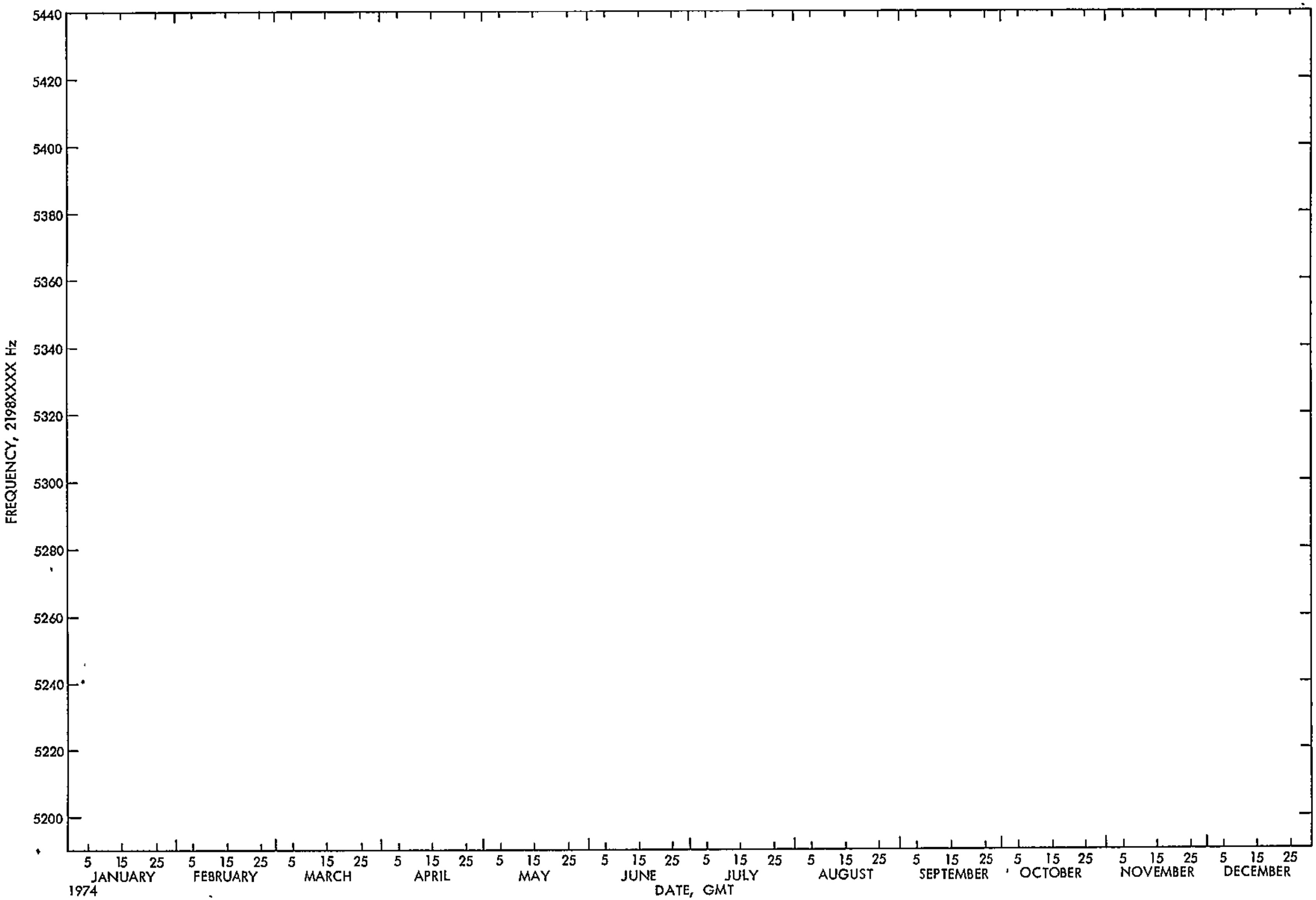


Fig. 35. Pioneer 11 channel 6 best-lock spacecraft receiver frequency, 1974

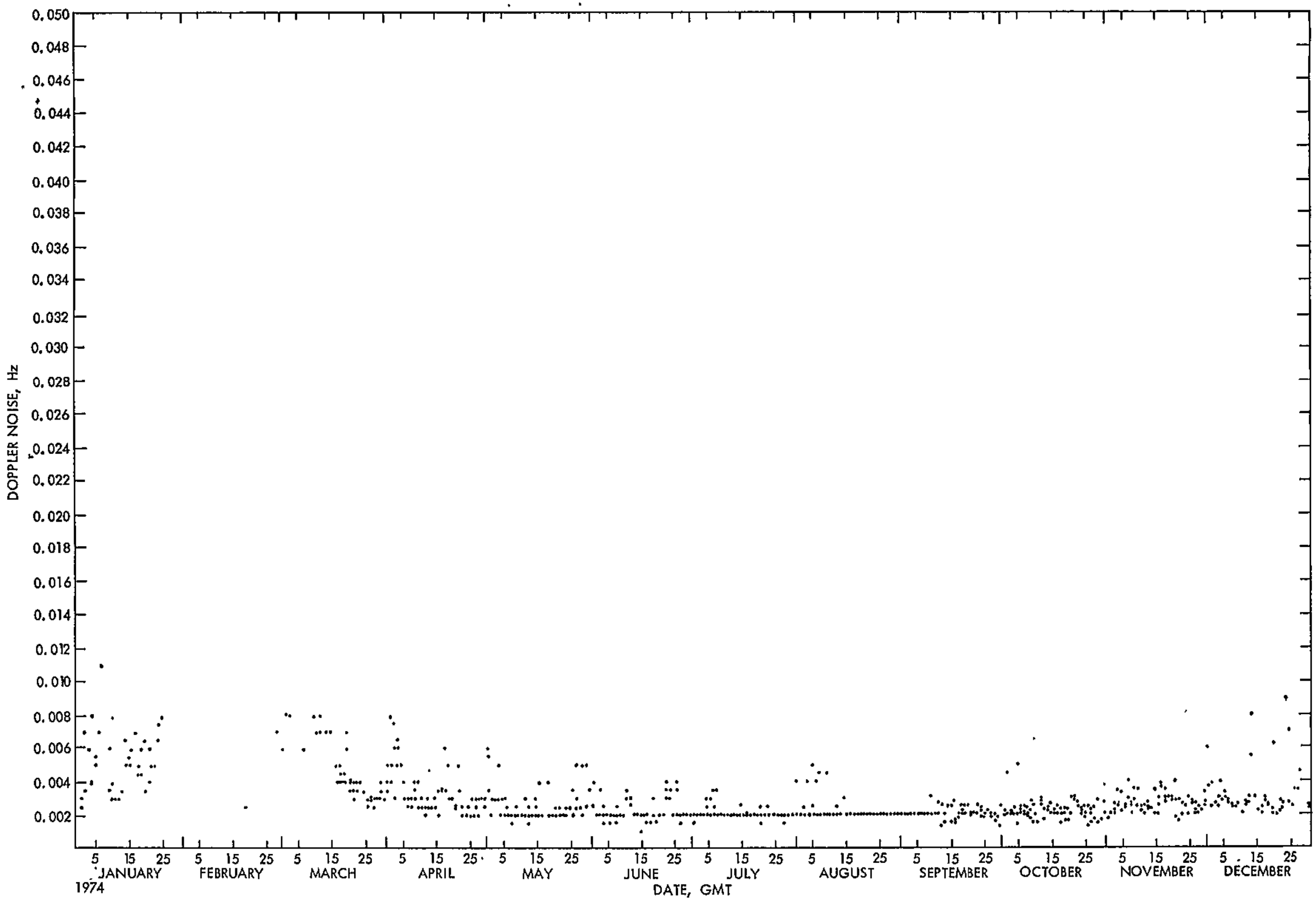


Fig. 36. Pioneer 10 doppler noise plot

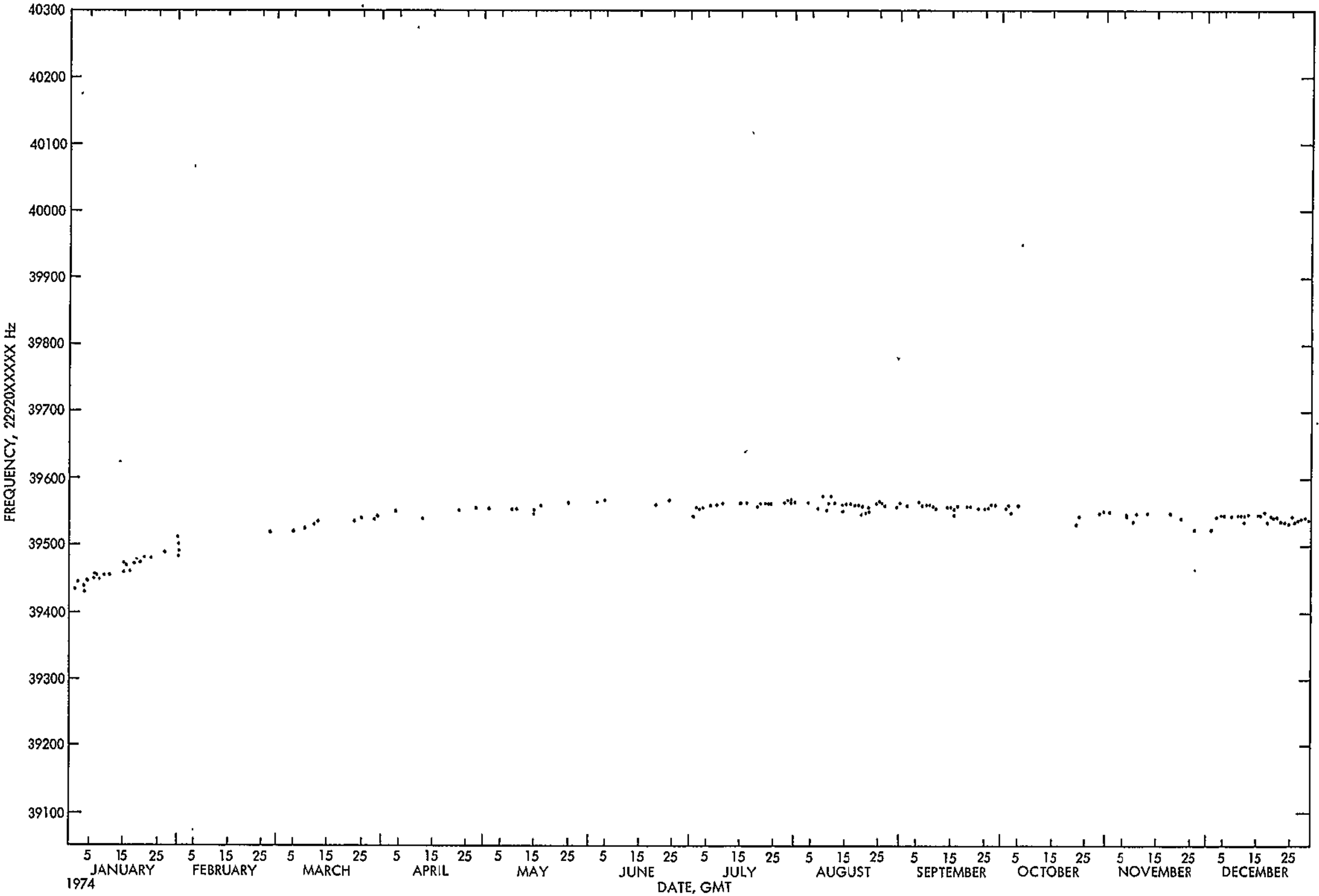


Fig. 37. Pioneer 10 on-board noncoherent oscillator frequency (TFREQ)

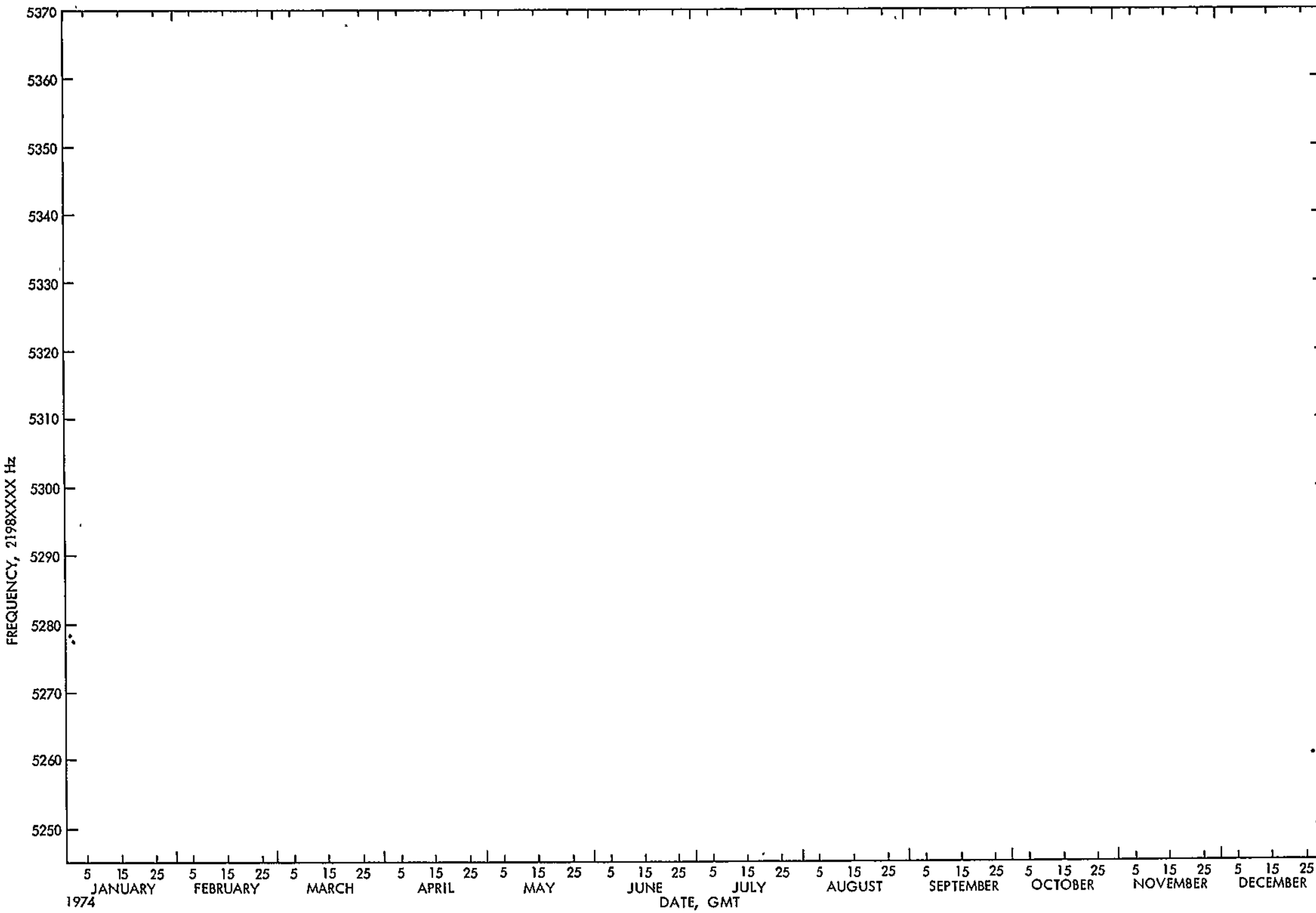


Fig. 38. Pioneer 10 channel 6 best-lock frequency

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DEFINITION OF ABBREVIATIONS

ACS	Attitude Control System
ACQ	acquisition
ADSS	Automatic Data Switching System
AGC	automatic gain control
APS	Antenna Pointing Subsystem
ARC	Ames Research Center
CMA	Command Modulator Assembly
CMO	Chief of Mission Operations
COE	Cognizant Operations Engineer
CP	Communications Processor
CPS	Central Processing System
CSE	Cognizant Sustaining Engineer
DCO	digitally controlled oscillator
DDA	Data Decoder Assembly
DIS	Digital Instrumentation Subsystem
DODR	Digital Original Data Record
DOY	day of year
DSS	Deep Space Station
ECO	Engineering Change Order
ELA	Earth look angle
EOM	end of mission
EOT	end of track
ET	Ephemeris Time
FPAC	flight path analysis and computation
FTS	Frequency and Timing Subsystem
GCF	Ground Communications Facility

GDS	Ground Data System
GMT	Greenwich Mean Time
GOE	ground operations equipment
HSD	high-speed data
HSDL	high-speed data line
IDR	Intermediate Data Record
IPP	imaging photopolarimeter
IRS	Information Retrieval System
IRV	Inter-range Vector
JPL	Jet Propulsion Laboratory
LTDS	Launch Trajectory Data System
LOS	loss of signal
MCCC	Mission Control and Computing Center
MCD	monitor criteria data
MDE	mission-dependent equipment
MDF	Master Data File
MDR	Master Data Record
MOCC	Mission Operations Control Center
MOS	Mission Operations System
MVM'73	Mariner Venus-Mercury 1973
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications Network
NAT	Network Analysis Team
NCS	Network Control System
NDP	Network Data Processing
NOAG	Network Operations Analysis Group
NOC	Network Operations Control
NOCC	Network Operations Control Center

NOCT	Network Operations Control Team
NOPE	Network Operations Project Engineer
NSP	NASA Support Plan
OC	Operations Chief
OCIS	Office of Computing and Information Systems
OCT	Operations Control Team
OD	orbit determination
ODC	Operations Data Control
ODR	Original Data Record
ORT	Operational Readiness Test
OSCO	Operations Support Coordination Office
OVT	Operational Verification Test
PDS	polarization diversity S-band
PET	probe ephemeris tape
PMCC	Pioneer Mission Control Center
PMOC	Pioneer Mission Operations Center
PMOCC	Pioneer Mission Operations Control Center
PMSA	Pioneer Mission Support Area
PPO	Pioneer Project Office
RCA	radius of closest approach
RCC	Remote Control Center
RIC	Remote Information Center
RTCS	Realtime Computing System
RTG	radioisotope thermoelectric generator
RTLT	round-trip light time
S/C	spacecraft
SCE	spacecraft event time
SDR	System Data Record

SEP	Sun-Earth-probe
SIRD	Support Instrumentation Requirements Document
SMT	S-band megawatt transmit
SNR	signal-to-noise ratio
SNT	system noise temperature
SOE	Sequence of events
SPD	S-band polarization diversity (cone)
SPE	static phase error
SPU	S-band polarized ultracone
SSA	Symbol Synchronizer Assembly
TCD	Telemetry and Command Data Handling Subsystem
TCP	Telemetry and Command Processor
TDA	Tracking and Data Acquisition
TDH	Tracking and Data Handling
TDS	Tracking and Data System
TLM	telemetry
TSF	track synthesizer frequency
UT	Universal Time
VCO	voltage-controlled oscillator
XRO	X-band receive only

APPENDIX

PIONEER 11 PASS CHRONOLOGY FOR ENCOUNTER PERIOD, NOVEMBER 3, 1974 TO JANUARY 3, 1975

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PASS CHRONOLOGY FOR ENCOUNTER PERIOD

GENERAL			
DSS	14	43	63
PASS	0578	0578	0579
DAY	307	307	307
AOS	00:35	08:00	15:28
LOS	08:40	15:45	00:50
TOT	08:05	07:45	09:22
DSS T	10:12	09:31	11:09
COMMAND			
TOT	244	26	53
TELEMETRY			
DL	150.9	150.7	151.0
RES	.0	.2	-.1
BR	2048	2048	2048
SNR	3.1	4.2	3.4
RES	.8	.9	.5
TRACKING			
MODE	2	2	2
T PWR	10	10	10
D RES	N/A	-.795	-.760
D NOS	N/A	.002	.002
E NOS	N/A	.002	.002

COMMENTS

DSS 14/P0578	DR 1989 FAILURE OF CONTROLLER TO NOTIFY OF B/R CHANGE
	DR 1837 ON DOPPLER BLUNDER POINTS
	DR 1990 TCP DOWN. TIMER PROBLEM
DSS 43/P0578	DR 1838 EXCESSIVE LOG ERROR WRITES
DSS 63/P0579	DR 1991 DCA ALARMS 002(DDB RATE WVERRUN)
	DDA 1 UNABLE TO FIX BY RELOAD. NO TLM B/U BUT CMD B/U OK

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0579	0579	0580	0580	0580	0581	0581	0581	0582
DAY	308	308	308	308	309	309	309	310	310
AOS	00:20	07:47	15:14	23:29	05:41	15:10	23:17	05:41	15:10
LOS	08:35	15:35	23:50	06:06	15:30	23:45	06:05	15:30	23:41
TOT	08:15	07:48	08:36	06:37	09:49	08:35	06:48	09:49	08:31
DSS T	10:00	09:34	10:21	08:19	10:23	11:32	07:54	12:17	10:25
COMMAND									
TOT	5	8	1	4	83	44	17	8	0
TELEMETRY									
DL	150.4	151.5	149.8	150.0	151.5	151.6	150.5	151.1	151.2
RES	.5	-.6	1.1	1.0	-.5	-.6	.5	-.1	-.2
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	3.7	4.2	3.5	3.9	3.7	3.0	3.9	4.2	3.0
RES	0.7	1.0	.6	.8	.6	0.1	1.0	1.0	0.2
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	10	10	10	10	10	10
D RES	N/A	-.753	-.752	N/A	-.755	-.746	-.755	-.739	-.733
D NOS	N/A	.002	.002	N/A	.002	.003	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0582	0582	0583	0583	0583	0584	0584	0584	0585
DOY	310	311	311	311	312	312	312	313	313
AOS	23:19	05:14	15:01	22:58	05:18	14:58	23:00	05:13	14:54
LOS	06:00	15:26	23:35	05:57	15:15	23:31	05:50	15:15	23:25
TOT	06:41	10:12	08:34	06:59	09:57	08:33	06:50	10:02	08:31
DSS T	07:30	11:49	10:04	08:41	11:29	10:01	09:26	15:41	10:14
COMMAND									
TOT	1	8	45	13	8	0	2	8	44
TELEMETRY									
DL	151.5	151.0	151.4	151.4	151.5	151.6	150.7	151.7	151.4
RES	-.5	.6	-.3	-.3	.2	-.5	.9	N/A	.2
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	3.7	4.0	3.6	2.9	3.9	3.1	3.4	4.2	3.0
RES	0.7	1.3	0.8	0.5	1.3	0.3	1.0	1.7	.8
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	20	10	10	10	10	10
D RES	-.754	-.732	-.728	-.743	-.726	-.722	-.736	-.718	-.718
D NOS	.003	.002	.002	.002	.003	.005	.003	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 14/P0582 DR 2005 OP. ERROR: CMA VALIDATION
DR 2006 OP. ERROR: M/E WRAPPED UP IN CW DIR
HIT PRE-LIMITS.

DSS 63/P0584 DR 1845 HIGH DOPPLER NOISE. DUE TO SYNTH JITTER

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0585	0585	0586	0586	0586	0587	0587	0587	0588
DOY	313	314	314	314	315	315	315	316	316
AOS	23:01	05:17	14:49	23:05	10:45	14:40	22:48	05:04	14:41
LOS	05:55	15:10	23:25	05:45	15:40	23:20	05:40	15:05	23:17
TOT	06:54	09:53	08:36	06:40	04:55	08:40	06:52	10:01	08:36
DSS T	09:10	11:24	10:22	08:54	05:46	11:46	07:28	12:56	01:03
COMMAND									
TOT	11	8	42	1	8	49	8	8	55
TELEMETRY									
DL	152.1	151.0	151.2	151.1	151.7	150.9	151.2	152.0	151.7
RES	-.5	.7	N/A	.6	.0	.8	.5	-.7	-.4
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	3.3	3.8	2.9	3.2	3.8	2.0	3.2	3.3	2.2
RES	1.3	1.2	0.1	1.0	1.3	0.8	1.1	.3	-0.5
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	10	10	10	10	10	10
D RES	-.731	-.709	-.715	-.751	-.703	-.691	-.715	-.698	-.697
D NOS	.002	.002	.002	.004	.004	.002	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 43/P0585 DR 1847 DIS LGWR ERRS EXCESSIVE; SUSPECT
TAPE QUALITY PROBLEMS

DSS 14/P0586 DR 1848 HIGH DOPPLER NOISE THRU OUT PASS

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0588	0588	0589	0589	0589	0590	0590	0590	0591
DAY	316	317	317	317	318	318	318	319	319
AOS	22:34	04:58	14:45	22:47	06:15	14:37	22:35	04:52	14:31
LOS	06:45	15:11	23:10	07:00	14:55	23:10	05:30	14:50	23:05
TOT	08:11	10:13	08:25	08:13	08:40	08:33	06:55	09:58	08:34
DSS T	09:09	10:45	10:24	09:56	10:21	10:44	09:20	11:41	08:29
COMMAND									
TOT	7	9	2	9	8	45	1	8	43
TELEMETRY									
DL	151.3	150.9	153.0	151.9	151.2	151.3	152.1	151.0	152.3
RES	.5	1.2	-1.2	-.1	.6	.0	-.7	.9	-.9
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	3.5	3.9	3.1	3.8	3.4	2.2	3.7	3.6	3.1
RES	0.9	1.2	.6	1.1	.7	-.1	0.9	0.8	1.1
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	10	10	10	100	10	10
D RES	-.710	-.695	-.689	-.708	-.689	-.688	-.698	-.681	-.678
D NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 63/P0589 DR 1854 D/L RESID OUT OF LIMITS

DSS 63/P0590 DR 1856 DIS AGC BAD

DR 2019 HIGH OLR BOTH TCP'S DUE TO XMTR NOISE SPIKES

DR 2020 ANTENNA PWR SUPPLY BREAKER TRIPPED

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0591	0591	0592	0592	0592	0593	0593	0593	0594
DAY	319	320	320	320	321	321	321	322	322
AOS	22:38	04:55	14:27	22:27	04:59	14:27	22:20	04:41	14:20
LOS	05:25	14:50	23:00	05:20	14:45	22:55	05:15	14:40	22:50
TOT	06:47	09:55	08:33	06:53	09:46	08:28	06:55	09:59	08:30
DSS T	08:29	11:23	10:18	08:29	11:37	10:45	08:29	12:03	11:10
COMMAND									
TOT	24	9	94	1	10	48	4	8	326
TELEMETRY									
DL	151.4	151.9	152.3	151.3	151.1	152.4	151.1	151.9	151.0
RES	.5	-.5	-.9	.1	.5	-1.0	.4	.0	.5
BR	1024	2048	2048	2048	2048	2048	2048	2048	2048
SNR	4.4	3.6	2.8	3.7	3.6	2.7	3.7	3.5	3.0
RES	-1.2	0.5	-0.1	0.6	0.6	.5	0.5	.5	0.2
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	20	10	10	20	10	20	100	10	10
D RES	-.695	-.678	-.676	-.692	-.673	-.670	.692	-.672	-.667
D NOS	.002	.001	.002	.002	.001	.002	.002	.006	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 63/P0594 DR 1859 COMMANDS 10-4 AND 11-17 DID NOT CLOCK-OUT

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0594	0594	0595	0595	0595	0596	0596	0596	0597
DOY	322	323	323	323	324	324	324	325	325
AOS	22:10	04:48	14:19	22:15	04:43	15:05	22:25	04:33	14:06
LOS	05:10	14:35	22:50	05:10	14:50	23:09	05:05	14:30	22:40
TOT	07:00	09:47	08:31	06:55	10:07	08:49	06:40	09:57	08:34
DSS T	08:39	11:32	10:33	08:02	10:10	10:56	08:02	11:40	14:37
COMMAND									
TOT	1	56	185	3	9	156	0	17	151
TELEMETRY									
DL	150.6	151.5	152.0	150.9	151.9	153.8	150.2	150.9	151.7
RES	1.1	-.2	-.5	.2	-.3	-2.2	1.4	.7	-.1
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	3.6	3.4	2.7	3.1	3.4	2.8	3.3	3.5	2.8
RES	0.4	.3	-0.2	.6	.3	.1	.2	.4	0.1
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	10	10	20	10	10	10
D RES	.687	-.673	-.668	.283	-.264	-.235	-.270	-.250	.237
D NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 43/P0594 1412Z REDUCED TXR PWR TO MINIMIZE ARCING-NO DR

DSS 63/P0596 DR 2111 AOS DELAYED DUE TO ELECTRICAL ANT DRIVE INTERFACE PROBLEMS SKY VALVE FAILURE

DSS 14/P0596 DR 2113 POLARIZER SWIN "LINEAR VICE" RCP

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0597	0597	0598	0598	0598	0599	0599	0599	0600
DOY	325	326	326	326	327	327	327	328	328
AOS	22:10	04:25	14:07	22:07	04:11	13:59	21:58	04:20	13:55
LOS	05:00	14:25	22:35	04:55	14:20	23:45	04:55	14:15	22:30
TOT	06:50	10:00	08:28	06:48	10:09	09:46	06:57	09:55	08:35
DSS T	08:27	11:38	10:47	08:55	11:30	13:06	09:12	12:21	10:47
COMMAND									
TOT	11	8	212	1	17	163	9	8	163
TELEMETRY									
DL	151.1	151.4	152.1	151.2	151.6	152.1	151.5	151.3	152.2
RES	.5	.2	-.5	.4	.1	-.4	.2	.4	-.5
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	3.6	3.5	2.7	3.7	3.5	2.8	3.4	3.6	2.9
RES	0.6	0.4	0.2	0.8	0.5	N/A	0.6	0.5	0.2
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	20	10	10	100	10	10	100	10	10
D RES	-.254	.232	-.216	-.230	-.211	-.195	-.204	-.183	-.166
D NOS	.002	.002	.002	.001	.002	.002	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 14/P0597 DR 2115 OPR ERROR-WRONG TCP MED ENTRY-FMT CHG WRONG DAY; CLOSED IN REAL TIME

DSS 14/P0598 DR 2119 TCP-A HALT

DSS 43/P0599 TXR NOISE SPIKES CAUSING LOSS OF DATA PWR LOWERED TO SKW

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0600	0600	0601	0601	0601	0602	0602	0602	0603
DOY	328	329	329	329	330	330	330	331	331
AOS	21:47	04:09	13:51	21:50	04:12	13:48	21:56	04:07	13:44
LOS	06:20	14:15	23:38	06:15	14:10	22:20	07:54	14:05	22:20
TOT	08:33	10:06	09:47	08:25	09:58	08:32	09:58	09:58	08:36
DSS T	10:28	11:36	11:12	10:56	10:25	10:21	10:49	12:07	11:30
COMMAND									
TOT	1	64	112	144	226	137	59	135	114
TELEMETRY									
DL	152.0	152.1	152.1	152.3	150.8	152.0	151.3	152.3	152.3
RES	-.3	-.3	-.3	-.5	1.0	-.2	.5	-.5	-.5
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	3.4	3.3	2.9	3.0	2.9	2.9	3.4	3.0	2.3
RES	0.8	0.4	.2	0.6	0.2	.2	.7	0.2	-.3
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	100	10	10	10	20	10	100	10	10
D RES	-.174	-.147	-.127	-.135	-.105	-.071	-.078	-.048	-.015
D NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 43/P0600 DR 1867 EXCESSIVE DIS LOG WRITE ERRORS
DR 2124 MISSED TRANSFER-OPR ERROR

DSS 63/P0601 DR 1868 TEN MIN DISCREPANCY IN TIMING OF TCP-2
INTERMITTENT;CAUSING ELAPSED TIME COMMANDS

DSS 14/P0601 DR 2125 DCA HALT TCP-A

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0603	0603	0604	0604	0604	0605	0605	0605	0606
DOY	331	332	332	332	333	333	333	334	334
AOS	21:51	03:43	13:40	21:41	03:42	13:37	21:45	03:49	13:43
LOS	06:05	14:00	22:15	06:05	13:55	23:24	06:00	13:55	23:20
TOT	08:14	10:17	08:25	08:24	10:13	09:47	08:15	10:06	09:37
DSS T	09:15	12:47	12:38	09:14	12:44	11:53	08:53	12:28	11:32
COMMAND									
TOT	96	172	138	47	130	149	116	128	112
TELEMETRY									
DL	151.5	152.4	152.2	151.5	152.5	151.8	151.5	152.4	152.0
RES	.3	-.5	-.3	.4	-.6	.1	.4	-.5	-.1
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	3.0	2.6	2.9	3.1	3.3	2.4	3.0	3.2	3.1
RES	-0.1	-0.4	0.3	0.4	0.2	-.2	.5	.4	.7
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	100	10	10	20	10	10
D RES	-.010	.029	.081	.096	.142	.211	.247	.312	.397
D NOS	.002	.002	.002	.001	.002	.002	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 63/P0606 DR 2133 DCA-1 HANG-UP
DR 2132 TCP-B (BACK-UP) DDA-1 HANG-UP. BAD LOAD

GENERAL	
DSS	14
PASS	0606
DOY	334
AOS	21:36
LOS	05:55
TOT	08:19
DSS T	08:41
COMMAND	
TOT	115
TELEMETRY	
DL	151.3
RES	.7
BR	2048
SNR	3.3
RES	.8
TRACKING	
MODE	2
T PWR	100
D RES	N/A
D NOS	.002
E NOS	.002

COMMENTS

DSS 14/P0606 DR 2134 TCP-B (BACK-UP) PROGRAM HALTED

GENERAL									
DSS	43	63	14	43	63	14	43	42	63
PASS	0606	0607	0607	0607	0608	0608	0608	0608	0609
DOY	335	335	335	336	336	336	337	337	337
AOS	03:36	13:28	21:40	03:31	13:24	21:24	02:18	04:59	13:18
LOS	14:01	23:16	05:50	13:45	23:13	06:50	13:50	07:00	23:08
TOT	10:25	09:48	08:10	10:14	09:49	09:26	11:32	02:01	09:50
DSS T	12:24	14:33	08:32	12:42	11:55	10:09	12:49	02:38	13:15
COMMAND									
TOT	204	125	92	464	408	371	611	0	489
TELEMETRY									
DL	151.6	152.6	152.0	152.7	152.5	152.1	151.7	N/A	152.4
RES	.4	-.6	N/A	-.7	-.5	-.1	.3	N/A	-.4
BR	2048	2048	2048	2048	2048	2048	2048	N/A	2048
SNR	3.1	2.4	2.9	2.7	2.4	2.4	2.6	N/A	2.1
RES	0.4	-1.0	0.4	-.4	-.1	-0.3	-.5	N/A	-.2
TRACKING									
MODE	2	2	2	2	2	2	2	3	2
T PWR	20	10	20	10	10	100	20	0	10
D RES	-.282	-.298	-.364	-.404	-1.054	N/A	N/A	N/A	28.268
D NOS	.003	.005	.008	.005	.009	N/A	.006	N/A	.008
E NOS	.003	.002	.002	.002	.008	N/A	.006	N/A	.006

COMMENTS

DSS 14/P0608 DR 2138 0112Z-0148Z CMD ABORT F SUBCARRIER FREQ ERROR

DSS 42/P0608 BACK-UP FOR UPLINK ONLY

DSS 63/P0609 DR 1881 ELAPSED TIME ALARM

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0609	0609	0610	0610	0610	0611	0611	0611	0612
DOY	337	338	338	338	339	339	339	340	340
AOS	20:39	03:40	13:14	21:17	03:35	13:11	21:16	03:32	13:07
LOS	05:45	13:45	23:05	05:40	13:45	23:03	05:40	13:40	22:58
TOT	09:06	10:05	09:51	08:23	10:10	09:52	08:24	10:08	09:51
DSS T	09:53	11:53	10:30	08:50	11:31	11:36	08:59	12:07	11:18
COMMAND									
TOT	358	145	147	157	197	117	210	223	35
TELEMETRY									
DL	151.9	151.6	152.4	151.6	151.2	152.0	151.9	150.6	152.8
RES	.2	.5	-.3	.5	.9	.1	.2	1.5	-.7
BR	2048	2048	2048	2048	2048	2048	2048	2048	1024
SNR	2.8	3.0	2.6	3.6	3.0	2.7	3.5	3.0	5.2
RES	0.4	-.3	.2	0.9	.1	.3	0.7	0	.4
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	10	10	10	10	10	10
D RES	24.194	22.374	20.555	19.650	19.107	18.418	-.652	-.687	-.766
D NOS	.002	.002	.002	.002	.003	.002	.003	.003	.005
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0612	0612	0613	0613	0613	0614	0614	0614	0615
DOY	340	341	341	341	342	342	342	343	343
AOS	21:14	03:22	13:03	21:08	03:33	13:00	21:10	02:53	12:56
LOS	05:35	13:35	22:55	05:30	13:21	22:51	05:30	13:20	22:50
TOT	08:21	10:13	09:52	08:22	09:48	09:51	08:20	10:27	09:54
DSS T	09:03	11:55	11:32	09:06	11:16	12:06	09:22	10:43	11:27
COMMAND									
TOT	164	248	276	139	304	278	182	43	6
TELEMETRY									
DL	151.5	151.6	153.0	152.2	152.2	153.3	151.4	152.1	153.0
RES	.6	.5	-.9	.4	-.1	-1.2	1.2	.1	-.8
BR	2048	2048	2048	2048	2048	2048	1024	2048	2048
SNR	3.1	2.8	2.4	3.0	2.1	2.5	3.5	2.1	2.6
RES-	N/A	0.2	-0.1	0.5	0.2	0.2	0.5	0.2	0.1
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	10	10	10	10	10	10
D RES	-.856	-.892	-.982	-1.024	-1.114	-1.205	-1.284	-1.339	-1.433
D NOS	.003	.002	.002	.002	.002	.002	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 14/P0612 DR 2142 TCP-B HALT
DSS 14/P0613 DR 2143 COMMAND ABORT B. SUBCA FREQ LIMITS
DSS 43/P0613 DR 1892 DIS LOG WRITE ERRORS
DSS 63/P0614 DR 2144 TCP HALT BETA-DDA HALT

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0615	0615	0616	0616	0616	0617	0617	0617	0618
DOY	343	344	344	344	345	345	345	346	346
AOS	21:05	03:15	12:51	21:01	03:00	12:49	20:59	03:18	12:44
LOS	04:05	13:20	22:40	05:20	13:20	22:40	03:50	13:05	22:39
TOT	07:00	10:05	09:49	08:19	10:20	09:51	06:51	09:47	09:55
DSS T	09:03	12:24	11:14	10:02	12:10	11:52	07:34	12:11	12:12
COMMAND									
TOT	13	10	1	2	8.	0	7	4	53
TELEMETRY									
DL	152.0	151.9	153.1	151.2	151.8	153.2	152.1	152.8	153.4
RES	.7	.3	-.9	1.0	.4	-1.0	.1	-.6	-1.2
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	3.5	2.3	2.6	3.3	2.5	2.6	3.0	2.1	2.4
RES	0.5	0.3	0.3	0.6	.4	0.3	0.6	.5	0.3
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	10	10	10	10	10	20
D RES	-1.524	7.568	-1.666	-1.757	-1.824	-1.907	-1.982	-2.049	-2.151
D NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002
COMMENTS									

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0618	0618	0619	0619	0619	0620	0620	0620	0621
DOY	346	347	347	347	348	348	348	349	349
AOS	20:58	03:16	12:40	20:46	03:19	12:37	20:46	03:14	12:33
LOS	05:15	13:05	22:36	03:45	13:00	21:26	03:40	12:55	21:25
TOT	08:17	09:49	09:56	06:59	09:41	08:49	06:54	09:41	08:52
DSS T	08:49	10:50	10:48	07:22	11:58	09:08	07:29	11:50	22:25
COMMAND									
TOT	1	38	1	41	10	0	3	10	42
TELEMETRY									
DL	151.8	152.7	153.4	152.4	152.8	152.6	152.1	152.5	152.8
RES	.4	-.5	-1.2	-.2	-.6	-.4	.1	-.2	-.5
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	3.2	2.2	2.3	2.4	2.1	2.5	3.1	2.9	2.4
RES	.7	.7	-0.1	-0.4	.5	.1	.5	.8	0
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	20	10	10	10	10	10
D RES	-2.249	-2.303	-2.414	-2.482	-2.565	-2.672	-2.773	-2.825	.N/A
D NOS	.002	.002	.002	.002	.002	.003	.004	.006	.003
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002
COMMENTS									

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0621	0621	0622	0622	0622	0623	0623	0623	0624
DOY	349	350	350	350	351	351	351	352	352
AOS	20:47	03:04	12:30	20:43	03:06	12:26	20:38	03:06	12:22
LOS	03:35	12:50	21:16	03:39	12:50	21:05	03:40	12:45	21:10
TOT	06:48	09:46	08:46	06:56	09:44	08:39	07:02	09:39	08:48
DSS T	06:55	12:02	10:25	07:37	12:11	10:46	07:23	11:27	08:48
COMMAND									
TOT	9	10	48	1	11	233	70	10	2
TELEMETRY									
DL	152.7	153.5	152.8	152.7	153.7	153.5	152.7	153.8	153.6
RES	-.4	-1.2	-.5	-.4	-1.4	-1.2	-.4	-1.5	-.8
BR	2048	2048	2048	2048	2048	2048	2048	2048	2048
SNR	2.5	2.4	2.3	2.9	2.2	2.0	2.3	2.1	1.5
RES	0	0	-0.1	.5	.2	-0.4	N/A	0.3	-0.6
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	20	10	10	10	10	10	20	10	10
D RES	-3.040	-3.101	-3.218	-3.319	-3.381	-3.497	-3.603	-.280	-.277
D NOS	.002	.002	.003	.002	.002	.002	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

GENERAL									
DSS	12	43	63	14	43	63	14	43	63
PASS	0624	0624	0625	0625	0625	0626	0626	0626	0627
DOY	352	353	353	353	354	354	354	355	355
AOS	20:40	02:55	12:18	20:37	02:45	12:14	20:23	02:42	12:11
LOS	03:35	12:40	21:00	03:25	12:36	20:55	03:30	12:39	20:50
TOT	06:55	09:45	08:42	06:48	09:51	08:41	07:07	09:57	08:39
DSS T	09:13	12:18	10:29	08:45	11:25	10:38	07:27	11:26	09:36
COMMAND									
TOT	2	11	0	2	11	35	1	8	43
TELEMETRY									
DL	160.9	153.5	154.1	153.3	154.3	N/A	153.0	153.4	154.1
RES	.3	-.2	-.8	-.4	-.9	N/A	-.6	N/A	-.7
BR	128	2048	2048	2048	2048	512	1024	1024	1024
SNR	3.8	1.7	1.4	1.9	1.6	N/A	5.2	5.1	4.8
RES	0.4	-0.7	-0.2	0.2	-0.2	N/A	N/A	1.0	.7
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	20	10	10	10	20	10	10	10
D RES	N/A	-.282	-.281	-.304	-.292	-.300	-.308	-1.296	-.293
D NOS	.004	.002	.002	.002	.002	.002	.002	.002	.002
E NOS	.002	.002	.003	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 12/P0624 DR 2187 EXCESSIVE LOG WRITE ERRORS

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0627	0627	0628	0628	0628	0629	0629	0629	0630
DOY	355	356	356	356	357	357	357	358	358
AOS	20:23	02:44	12:08	20:21	02:36	12:05	20:15	02:34	12:00
LOS	03:20	12:30	20:50	03:15	12:25	20:45	03:10	12:20	20:47
TOT	06:57	09:46	08:42	06:54	09:49	08:40	06:55	09:46	08:47
DSS T	09:10	11:11	10:16	08:18	11:44	10:53	08:40	13:45	10:54
COMMAND									
TOT	8	9	0	6	9	0	8	36	8
TELEMETRY									
DL	153.2	153.3	153.8	152.6	152.8	153.5	152.9	152.6	153.5
RES	-.8	-.4	-.7	-.2	.1	-.6	-.5	.2	-1.1
BR	1024	1024	1024	1024	2048	1024	2048	2048	2048
SNR	5.4	5.1	5.2	5.8	2.3	5.2	2.6	2.7	2.2
RES	-.1	0.6	.8	-.5	0.9	.6	.2	1.0	0
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	20	10	10	10	10	10	10	10	10
D RES	-.318	-.304	-.301	-.327	-.308	-.309	-.333	-.318	-.319
D NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS
DSS 14/P0627 DR 2169 XMIT SPIKING
DSS 63/P0628 DR 2162 DIS-CRT INTERFACE HANG-UP. REINIT.
DSS 43/P0628 DR 2170 HIGH DELETION RATE ON ALPHA

GENERAL									
DSS	14	42	63	14	42	63	14	43	63
PASS	0630	0630	0631	0631	0631	0632	0632	0632	0633
DOY	358	359	359	359	360	360	360	361	361
AOS	20:14	02:51	11:58	20:15	02:33	11:51	20:04	02:26	11:50
LOS	03:20	12:20	20:40	03:25	12:15	20:35	03:05	12:13	21:20
TOT	07:06	09:29	08:42	07:10	09:42	08:44	07:01	09:47	09:30
DSS T	08:38	10:59	10:21	09:18	11:54	11:25	08:12	11:51	12:02
COMMAND									
TOT	42	4	43	10	11	1	70	9	2
TELEMETRY									
DL	2.9	160.3	153.3	152.9	160.1	153.1	152.5	152.2	153.3
RES	.6	.2	-.9	.4	.5	-.6	0.0	.3	-.8
BR	2048	256	2048	1024	256	2048	2048	2048	2048
SNR	2.9	1.6	2.3	3.1	1.4	2.1	2.6	2.7	2.4
RES	0.6	0.4	0	.4	.5	-0.1	0.7	0.1	.4
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	20	20	10	10	10	10	10
D RES	-.330	-.345	-.465	-.336	-.356	-.330	-.355	-.322	-.328
D NOS	.003	.002	.005	.002	.002	.002	.004	.002	.003
E NOS	.002	.002	.002	.002	.002	.002	.002	.004	.002

COMMENTS
DSS 42/P0630 DR 2207 DOPP RESID +800KHZ

GENERAL									
DSS	14	43	63	14	42	63	14	42	63
PASS	0633	0633	0634	0634	0634	0635	0635	0635	0636
DOY	361	362	362	362	363	363	363	364	364
AOS	20:45	02:14	11:45	20:00	02:26	11:45	19:54	02:22	11:40
LOS	03:00	12:08	20:30	02:58	12:05	20:25	02:55	12:00	20:29
TOT	06:15	09:54	08:45	06:58	09:39	08:40	07:01	09:38	08:49
DSS T	08:15	11:51	10:45	08:09	11:05	10:12	07:22	10:55	10:16
COMMAND									
TOT	17	1	3	13	262	1	15	10	1
TELEMETRY									
DL	153.5	153.0	153.1	152.3	160.5	153.5	152.7	160.4	153.7
RES	-1.0	-.5	-.6	.2	.1	-1.0	-.2	.2	-1.2
BR	2048	2048	2048	2048	256	2048	2048	256	2048
SNR	2.5	2.8	2.0	2.8	1.4	2.0	2.1	1.3	2.0
RES	0.8	0.1	-0.1	1.9	0.2	-0.1	0.3	-0.5	-0.1
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	10	10	10	10	10	10
D RES	-.360	-.341	-.346	-.365	-.378	-.368	-.351	-.383	-.358
D NOS	.004	.005	.002	.002	.003	N/A	.010	.003	.005
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 63/P0634 DR 2215 TRK DATA MISSING FROM TIME TO TIME

DSS 14/P0635 DR 2221 HIGH DOPP NOISE DR 2219 DIS LGWRS

DR 2021 INTERRMITTANT LOSS OF TLM LOCK ON TCP-B

GENERAL									
DSS	14	43	63	14	43	63	14	43	63
PASS	0636	0637	0637	0637	0638	0638	0638	0638	0639
DOY	364	364	365	365	001	001	001	002	002
AOS	19:55	01:56	11:35	19:51	02:05	11:30	19:48	02:00	11:30
LOS	02:50	11:55	20:20	02:45	11:50	20:15	02:45	12:00	20:23
TOT	06:55	09:59	08:45	06:54	08:45	08:45	06:57	10:00	08:53
DSS T	07:40	10:30	09:41	08:08	11:36	10:45	07:22	11:12	10:37
COMMAND									
TOT	71	9	45	82	9	0	1	2	4
TELEMETRY									
DL	152.6	152.9	153.8	153.3	154.1	153.9	153.6	153.3	154.7
RES	-.1	-.4	-1.2	-.2	-.8	-1.3	-.4	.3	-1.6
BR	2048	2048	2048	2048	2048	1024	1024	1024	1024
SNR	2.0	2.3	2.1	1.6	2.2	4.9	4.5	4.5	3.8
RES	-0.2	-0.4	.1	.4	-.1	-.1	0.4	.3	-0.9
TRACKING									
MODE	2	2	2	2	2	2	2	2	2
T PWR	10	10	10	20	10	20	10	10	10
D RES	-.148	-.371	-.369	-.015	-.005	-.026	N/A	-.014	-.027
D NOS	.003	.003	.003	.015	.004	.002	.002	.002	.003
E NOS	.002	.002	.002	.002	.002	.002	.002	.002	.002

COMMENTS

DSS 14/P0636 DR 2022 ANT BREAK

DSS 14/P0637 DR 2223 HIGH DOPP NOISE

GENERAL				
DSS	14	43	63	14
PASS	0639	0639	0640	0640
DOY	002	003	003	003
AOS	20:15	01:59	11:25	19:46
LOS	02:40	11:48	20:10	02:40
TOT	06:25	09:49	08:45	06:54
DSS T	07:05	11:11	09:16	08:02
COMMAND				
TOT	10	31	158	11
TELEMETRY				
DL	153.8	153.4	153.0	153.2
RES	-1.2	.2	.6	.3
BR	1024	1024	2048	1024
SNR	4.2	3.6	4.5	4.3
RES	-0.5	.2	0.4	0.6
TRACKING				
MODE	2	2	2	2
T PWR	20	10	10	20
D RES	-.041	-.007	-.040	-.041
D NOS	.003	.002	.002	.002
E NOS	.002	.002	.002	.002

COMMENTS

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